EDUCATION OF THE LEFT AND THE RIGHT

Implications of Hemispheric Specialization

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M.K. RAINA
National Institute of Education, New Delhi

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To my parents

The intellect is an organ composed of several groups of functions divisible into two important classes, the functions and faculties of the right hand, the functions and faculties of the left hand. The faculties of the right hand are comprehensive, creative and synthetic; the faculties of the left hand critical and analytic. To the right hand belong judgement, imagination, memory, observation; to the left hand comparison and reasoning. The critical faculties distinguish, compare, classify, generalise, deduce, infer, conclude; they are the component parts of the logical reason. The right-hand faculties comprehend, command, judge in their own right, grasp, hold and manipulate. The right-hand mind is the master of the knowledge, the left-hand is servant. The left-hand touches only the body of knowledge, the right-hand penetrates its soul. The left-hand limits itself to ascertained truth, the right-hand grasps that which is still elusive or unascertained. Both are essential to the completeness of the human reason. These important functions of the machine have all to be raised to their highest and finest working-power, if the education of the child is not to be imperfect and one-sided.

—SRI AUROBINDO
A System of National Education, 1924

Our educational system and modern society generally (with its very heavy emphasis on communication and on early training in the three R's) discriminates against one whole half of the brain. . . . In our present school system, the attention given to the minor hemisphere of the brain is minimal compared with the training lavished on the left or major hemisphere.

—ROGER W. SPERRY
Mosaic, March/April 1976

I feel you have to train people to combine what we might now call the left and the right-hand side of the brain, the intuitive and the analytical. There's a synergetic reaction there. If a person can be free enough to depend on his intuition and at the same time have the analytical rigor to keep things from becoming flaky, then you have something very powerful.

—ARTHUR LOEB
Span, December 1982

Foreword

The dual nature of the human mind and consciousness have been pointed out for thousands of years in literature, art, philosophy, and religion. However, practical people in education, business, industry, and the like have continued to be skeptical about the matter and have rarely made deliberate use of this information. In recent years, clinical and experimental studies have reduced this skepticism and there is now active interest in using information about the dual aspects of the human mind and consciousness to improve learning and thinking.

While scholars and educators have been arguing about the reality of the dual nature of the human mind and consciousness, considerable technology has been created and refined for using this dual nature of human mind and consciousness to improve chances of success in creative problem-solving. Theorists and practitioners in this field have long recognized that there are two basic patterns of learning and thinking or "processing information". In one pattern, logical, rational mind is dominant and in the other, the intuitive, creative, non-logical mind and other states of consciousness are dominant. All of the leading models of creative thinking and the resulting technology call for both patterns of information processing.

Alex F. Osborn (*How to Become More Creative*, Scribners, 1952) used the terms "critical intelligence" and "creative intelligence". He argued that these two kinds of intelligence could not function optimally at the same time and pioneered training methods for calling into play whatever kind of intelligence or information processing was needed. This resulted in the principle of deferred judgement, the rules for brainstorming or idea production, and the like.

Other creativity scholars and technologists have used similar sets of terms to talk about the same phenomena. Edward de Bono (*Lateral Thinking*, Harper & Row, 1970) has used the terms "lateral" and "vertical" thinking. Rollo May (*The*

Courage to Create, W.W. Norton, 1975) uses the terms "rational" and "suprarational". William J.J. Gordon (*Synectics*, Harper & Row, 1961) talks of the "intellectual" and the "irrational, emotional". In my work (Torrance, *What Research Says to the Teacher: Creativity*, National Education Association, 1963), I have used the concepts of "learning creatively" and "learning by authority". Edward de Bono, William J.J. Gordon, E. Paul Torrance, and a host of others have created a considerable amount of technology in the form of training procedures, school learning materials, and the like, for making use of the dual nature of human consciousness.

There is now the dawning of recognition that we have learned some facts about the human brain and its dual, triune, or wholistic nature that have important implications for everyday classroom practice, in business, and in all other human affairs. It appears that our schools, trainers in business and industry, and decision-makers generally have been focusing most of their energies on the left half of the brain. To develop all of a child's capabilities, we must have curricula and materials for engaging the whole brain. In business, industry, government, and other human organizations, decision-makers, planners, and other practitioners must have mastery of procedures for making use of all of their mental abilities.

Futurists have also turned attention to the dual or triune nature of the human mind. It is quite possible that the next important advances in forecasting the future may result from research now being done on the human brain. Evidence is mounting that the best predictions are made when forecasters draw on both sides of brain—the intuitive right hemisphere as well as the analytic, objective left hemisphere. Our best motivation comes from visualizing what we want, planning how to get it, and forecasting the probability of success down one route rather than another.

Management scientists have also focused attention on the dual nature of the human mind. Many experts in this field believe that tomorrow's managers will make increasing use of intuitive thinking skills to steer their organizations through the upheavals ahead. Scientists in this field believe that managers will need this new set of skills to cope successfully with the shifting environment resulting from accelerated change. The Japanese have apparently pioneered a management model or style that blends analysis and evaluation with the insights of intuitive thinking. Management education programs are creating courses and in-service training programs designed to develop intuitive skills.

There is a great need to maintain adequate balance in the process of creating new management training programs as well as new educational materials for school learning. Certainly it is time that we became more intuitive, non-linearly based, spatially and kinesthetically oriented. Western societies have looked down upon intuitive responses as whimsical and play and of no practical value. Now, however, it is becoming increasingly apparent that our future depends upon the creativity of right-brain thinking. Nevertheless, it is important that we now emphasize the right side to the extent that we have emphasized the left. It is important to educate and use the whole brain that is both intuitive and rational. This goal should be a future focus of education, parenting, business, industry, and every other aspect of human interaction. I am sure that it is Dr. Raina's dream that this book will make easier our movement to this focus.

E. PAUL TORRANCE
Alumni Foundation Distinguished Professor
The University of Georgia, Athens, GA, USA

September 1, 1983

Preface

Medical and neurological sciences can greatly enhance the effectiveness of education by their research into the nature of man and the limits of his potential. Planning education of the "whole child", without recognizing that the whole child is a complex neurological structure, will be utterly unrewarding. In 1872 Hughlings Jackson, the eminent British neurologist, gave the Hunterian Oration at Oxford University in which he said: "In a physiological inquiry into education we must widen our field of investigation beyond the popular conception of mind. Much harm has resulted from an artificially abrupt separation betwixt mind and body." Even the late Alexander Luria also pointed this out, but few people recognized the truth of what he said so well. And, recently, Professor George Hynd has pointed out: The potential benefits to educational theory and practice through the application of neuropsychological knowledge may be more significant than presently imagined. In order that appropriate application of neuropsychological knowledge may be achieved, educators, even those who would resist this approach, must become more articulate in evaluating the neuropsychological literature.

The present volume describes recent advances in the field of split-brain research, carried out by Professor Roger W. Sperry and others over three decades, which forms the theoretical basis for much of the modern research into how the brain processes information. For Dr. Sperry, who received the 1981 Nobel Prize in Medicine, the Nobel Committee observed: "He has provided us with an insight into the inner world of the brain which hitherto had been almost completely hidden from us." This research has significant implications for medical, social, biological and behavioural sciences. For education it has many implications suggesting a radical change which necessitates unrelenting questioning of the unexamined presuppositions and assumptions about reality that pervade our classrooms, curriculum, teaching, textbooks and educational environment. This volume examines the inadequacies of the traditional patterns of education which are inadequate since they concentrate almost exclusively on developing some aspects of the brain and neglect many vital and crucial functions. This volume, therefore, suggests what the formal curriculum, teaching strategies and school experiences might do to accelerate the development of these neglected aspects or functions, stressing that education should aim at neurological symmetry. In the process of analysing and suggesting implications, I confess that some statements have been made which may be undoubtedly controversial. But, as Professor R.H. Hodgkin maintains, teachers need controversy so that they question ceaselessly the routine and uncreative processes within education. That obviously is their professional concern. There is much truth in the Zen statement: "No one can go to the bathroom for you."

In writing and developing this book, I have been helped, directly and indirectly, by many people. My special thanks are due to Dr. Joseph E. Bogen, Neurological Surgery, New Hope Pain Center Medical Group, California, who provided necessary stimulation and encouragement for writing an earlier paper which forms the basis for this volume. In fact, he has influenced most of my thinking in this area. How much I owe to him will become evident as one goes through this volume. Thanks are also due to Dr. Ron Rubenzer whose prepublication draft helped me in writing a portion of this book. Any misperception or errors may be attributed only to myself and none bears any responsibility for the defects that remain.

I am greatly indebted to the contributors to this volume for their prompt and enthusiastic response as well as for the innovative and creative nature of their chapters. Their contributions have enhanced the value of this book.

I owe a great debt to my father Mr. T.N. Raina and my brother Dr. Vijay K. Raina from whom I have received a lot of encouragement and support. Thanks are also due to Dr. Arunima Vats who has been of considerable help at various stages of the development of this book. The editorial assistance provided by Mrs. Brinda Ramesh is gratefully acknowledged.

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M.K. RAINA

Contributors

JOHN C. GOWAN is Professor of Education at San Fernando Valley State College, Northridge, California.

JOE KHATENA is Professor and Chairman, Department of Educational Psychology, Mississippi State University, Mississippi.

ROBERT B. LIVINGSTON is Professor of Neurosciences, University of California, San Diego; former Chairman, Commission on Science Education, American Association for the Advancement of Science.

CECIL R. REYNOLDS is Associate Professor and Director, School Psychology Training Programme, the Department of Educational Psychology, Texas A & M University, Texas.

CONRAD F. TOEPFER works at the State University of New York at Buffalo, Buffalo.

E. PAUL TORRANCE is Alumni Foundation Distinguished Professor, College of Education, The University of Georgia, Georgia.

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PART I

Education and the Growth Sciences: The Role of Neurosciences

The effectiveness of any educational process largely depends on the extent to which it rests upon human nature and the nature of experience. In education, "the goals we seek, the things we do, the judgements we are willing to try are determined by our belief about the nature of man and his capacities" (Combs, 1962). Humans, therefore, will have to be understood in their actualities, in their possibilities and in their idealities—in short in their totalities. This is possible when those working in the field of education draw upon various scientific and biological disciplines (Suppes, 1973). All these areas, as Cremin (1976) maintains, will clearly have a stake in any systematic research into the processes of education and elucidating certain aspects or dimensions of what human beings are. The working out of educational theory in relation to its various parent disciplines can give education intellectual rigour and responsibility (Elvin, 1977). The Report on *Learning to be* (Faure, 1972) also emphasized that such fields as biology, neuropsychology, genetic epistemology, linguistics, information theory, semiology and cybernetics play an important role in the formulation of what can be called general system theory of education. Therefore, any question of restructuring or reformulating or reforming educational content or methodology or even educational objectives can be a valid exercise if it takes into account new knowledge about man and the way in which man interacts with his environment and fellowmen (Nagchaudhuri, 1975). There is often a wide gap between our understanding of the nature of human behaviour on the one hand and the utilization of such understanding in the classroom on the other. We ought to be able to develop on the basis of new insights better programmes of instruction. That new insights do not always come with their best use at once is apparent and sometimes they have to be puzzled out (see Bowers, 1967; and Burner, 1971). New insights often serve to strengthen or extend present undertakings in ways that enrich our thinking, without necessarily redirecting it (Combs, 1963). We have to learn the "art of receptivity", to be open to new insights, rid ourselve of delusory icons. Myopia and confusion are forgivable in the general public but intolerable in a group that is supposed to lead its field (Sizer, 1973).

To strengthen educational processes and reach educational goals, workers have made interesting and visionary speculations. Some educators (Krech, 1977) have suggested the use of enzyme-assisted instruction, protein-memory consolidators, and antibiotic memory repellers. These speculations would automatically suggest the need for a multihybrid expert—psychoneurobiochemist educator—who will look at education and mind from psychoneurobiochemopharmacopia point of view. Therefore, to understand human nature in the proper perspective and make education effective, educationists will have to take both 'electricity' as well as 'juices' into consideration.

Recent spectacular advances in the neurological sciences have stimulated the hope that the application of the newly developed concepts and findings will lead to a breakthrough in the understanding of educational processes, notably learning, memory, attention, thinking and evaluation. Such neurological and neurochemical research has profound implications since, as Alexander Luria maintained, it enables us to probe more deeply into the structures of psychological processes than straightforward phenomenological description can. Gradually it is being appreciated that there is considerable overlap between the problem of educational, sociological and psychological processes and those of neurobiology, neuropsychology and related disciplines, and there is every possibility of reciprocal assistance. Researchers in these fields are willing to approach complex functions on a physiological basis. They believe that the techniques of neurosciences can provide a service to education at all stages throughout life (Livingstone, 1975). Neurosciences can provide explanations of the causes of severe reading and language disabilities and prescribe better methods of treating these disabilities. They can also provide explanations of strengths and weaknesses in cognition and learning that were not based primarily on motivation, parent-child relations, emotional or other psychological factors. Neurosciences also have a considerable impact on the diagnosis and treatment of children who have severe difficulty in learning academic skills. The brain is constantly growing and changing, and teachers need to be appraised of the changes that may affect the ability of the pupil to respond to different kinds of learning. This view of the changing, plastic brain requires not only extra vigilance and care (on the part of educators), but also brings with it greater opportunities. Neurological hypotheses and theories will need to be tested and applied in classrooms and clinics. And knowledge from the classroom and from educational research will need to be fed back to the neuroscientists for the modification and refinement of their theories (Chall and Mirsky, 1979). Quite revealing and insightful speculations have been made by Chall and Mirsky (1979) about the future scenario regarding collaboration of education with neurosciences.

"It is tempting to speculate on a possible future collaborative effort between educators and neuroscientists as we enter the twenty-first century. Conceivably, a new speciality of educational neuroscientist, or educational neuropsychologist could emerge and would combine both kinds of expertise. The discipline of neuropsychology itself is such a blend of interests and skills, and now includes a relatively new subspeciality of clinical neuropsychology. The new professional of whom we speak would be well versed in all of the latest pedagogical information concerning effective methods of teaching and modern developments in curriculum; in addition, this person would be trained in neuropsychological and neurophysiological knowledge and techniques. Each child in the school system needing special assistance would, according to this scheme, be tested by this new professional.

"The test battery of the twenty-first century would be the responsibility of a team of specialists including the educational neuroscientist. It would encompass behavioural and photographic analyses designed to identify motor patterns, cerebral dominance and related psycho- and physiomotor capacities; it might also include electrographic and sensory tests that would provide data about the relative maturity and efficiency of processing information in all relevant sensory modalities. Attentional capacities would be assessed by both behavioural and electrophysiological means, and the sources of attentional difficulties (if any) categorized and identified with respect to intra- as opposed to extra-cerebral causes. Brain size, maturity, and relative degree of myelinization in key areas would be assessed by means of noninjurious neuroradiological techniques (the progeny of today's computerized axial tomography scanners). Oxygen utilization in various brain regions, at rest and during a variety of mental activities, would be assessed by means of dynamic energy utilization techniques. Such methods currently exist and need only to be refined further. Brain neurohumoral balance and maturity would be assessed by means of biochemical assays performed on a few drops of urine and blood. Computer-assisted analyses of these data would enable the educational neuroscientist to perform an accurate assessment of the child's developmental stage, his particular strengths and weaknesses, the instructional materials he would best be able to handle, and the problem areas that would most likely be encountered during his educational career. This information would be made available to the child's teacher or teachers, and would be continuously updated and upgraded at regular intervals.

"This programme would permit the early identification, forecasting and remediation of educational difficulties; but, more than that, it should help in the development of a pedagogical effort and programme designed on the basis of how each child is growing and maturing, on each child's talents and weaknesses, and not on the basis of an average, normative set of values that fits any single pupil on only a loose way.

"As exciting as this Utopian aid to education may be available in the twenty-first century or a few years earlier, but it must be realized that it cannot be applied in the absence of that most effective and essential of all educational forces—able, patient and caring teachers."

One recent significant development in neurophysiology which clearly is important for education is that of hemisphericity and knowledge about complementary hemispheric specializations. "Few topics in the neurosciences can match the study of cerebral lateralization in its power to stimulate the imagination of people" (Kinsbourne and Hiscock, 1978). It has provided extensive data relevant to understanding the processes of human learning, thinking, creativity, reading and, therefore, to improve the curriculum and the methods of teaching. These developments will hopefully have synergistic effects on the improvement of all educational practices. Researches on cerebral hemispheres and their functioning suggest many exciting possibilities for educators to exploit. These researches also indicate some of the serious inadequacies in the present educational practices and the misplaced emphasis on certain aspects at the cost of more vital and significant dimensions.

Hemispheric Specialization: Research Evidence

The human brain—the most crucial part of the anatomy—is the most complex mechanism known to man. It has been studied and restudied from every imaginable angle, using highly ingenious and elaborate methods. Research and speculation about cerebral hemispheres and cerebral dominance extends back to almost 150 years (Dax, 1836) and is still a topic of considerable interest and attention (Bogen, 1977; Chall and Mirsky, 1978; Ehrlichman and Weinberger, 1978; Kinsbourne and Hiscock, 1978; Tandanobu, 1978; Thompson, Bogen, and Marsh, 1979; Bradshaw and Nettleton, 1981). Innovative research from the late sixties onwards has made considerable advances in understanding and explaining the functional asymmetry of the humain brain and it has supported Hippocrates' contention: "the human brain, as in the case of all other animals, is double" (Bogen, 1969). The duality was apparent to Plato as well who, according to an account by Cicero (Rather, 1965), divided the mind into separate entities: "one partaking of reason and the other devoid of it". The historical interest in the asymmetry is well documented in Bogen (1969) and Corballis and Beale (1976).

By working with patients who have had the two hemispheres (right and left: which are intimately related to the consciousness of the person) (Eccles, 1981) of their brains surgically separated in an attempt to stay the spread of malepileptic seizures, Roger Sperry (1975) of the California Institute of Technology and Joseph Bogen (1969) of the Ross Loss Medical Group

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I am grateful to Ron Rubenzer (1978) for making available to me a prepublication draft of his monograph which proved of great help in writing this and the next chapter.

Dr. J.E. Bogen is currently at New Hope Pain Center Medical Group, California.

and their associates (Bogen, Fisher, and Bogen, 1965; Gazzaniga, 1970, Gazzaniga and Sperry, 1967; Sperry, 1968; Galin, 1974; Duke, 1968; Galin and Ornstein, 1974) have confirmed what John Hughlings Jackson asserted in 1878 that our brain consists of two distinctive but anatomically symmetrical units, the right and the left hemispheres. These studies on the functioning of the human brain, together with the new findings, indicate that the two hemispheres of the cerebral cortex process, organize and encode information differently. Each cerebral hemisphere is capable of functioning in a manner different from the other. For most right-handed persons, the left hemisphere treats stimuli serially, one at a time, whereas the right hemisphere processes stimuli many at a time as a gestalt. This functional difference renders each hemisphere superior in performing certain types of tasks; the left hemisphere is better at such tasks as reading, speaking, analytical reasoning, and arithmetic, and the right hemisphere is better at spatial tasks, recognizing faces, and music. It is considered to be spatial, holistic and simultaneous in nature.

Cortical hemispheres overlap greatly in ability and function and are richly connected with each other through the cerebral commissures and other tissues. The so-called dichotomy between the hemispheric functions probably results from a slight advantage one strategy has over the other, which is sufficient to produce specializations of some functions. As Luria (1973) indicates in an excellent summary of the functional organization of the brain, it is hierarchically organized to integrate messages coming from lower sources. The brain also specializes within each hemisphere as well as across the hemispheres. No dichotomy of function does justice to the sophistication and complexity of the human brain.

EVIDENCE FOR HEMISPHERIC SPECIALIZATION

In an effort to establish such a duality and correlational relationships between cognitive functioning and hemispheric processing several methods of investigation have been employed. Evidence has come for hemispheric specialization from many diverse investigations, from anatomical to behavioural.

Empirical support for the encoding strategies of the cortical hemispheres comes from research with commissurotomized patients, patients with unilateral brain damage, and normal people given dichotic listening tasks, dichotic visual tasks, questions, sets and instructions designed selectively to stimulate attention in one or the other cortical hemisphere. Several methods of investigations have been adopted. A review of representative studies made by Rubenzer (1978), conducted primarily within the last ten years, suggests that the investigative techniques employed can be classified in three major categories: medical intrusive, medical non-intrusive and non-medical non-intrusive. Studies have also been classified into various categories on the basis of the techniques followed (Wheatley, Frankland, Mitchell, and Kraft, 1978). The following section presents details about these studies.

LESION STUDIES

On the basis of extensive clinical studies of patients with well lateralized brain lesions, functional differences in the left and the right hemispheres were first noted. Such studies (Ettlinger, Warrington, and Zangwill, 1957; Luria, 1976; Milner, 1971; Geschwind, 1970) indicated that right hemisphere lesions resulted in loss of spatial ability, whereas left hemisphere lesions resulted in loss of speech and reasoning ability. Bogen (1969a, 1969b) and Bogen and Bogen (1969) presented detailed summaries of lesion studies.

ANATOMICAL EVIDENCE

It has been observed that when the relative shape and size of the hemispheres of a human brain are examined, definite differences become clear. For example, in examining 100 adult and 100 infant brains, Wada, Clark, and Hamon (1975) found anatomical evidence for left hemisphere speech. Geschwind (1974), Geschwind and Levitsky (1968), and Witelson and Pallie (1975) report convincing evidence to support specialization of the hemispheres: the left hemisphere in linguistic processing and the right hemisphere in spatial processing.

SPLIT BRAIN RESEARCH

The ingenious work initiated by Roger Sperry resulted in a great amount of lateralization of cerebral functioning. Such studies have involved direct surgical inspection or alteration of the brain structure or function. Methods within this category include, but are not limited to commissurotomy, electroconvulsive therapy (ECT), hemispherectomy, lobectomy and lobotomy. Commissurotomy or "split-brain research" (Gazzaniga, 1967) involves the severing of the connection between the two halves of the brain or the corpus callosum. This technique was used to eliminate epileptic seizures (Ornstein, 1972; Levy, Trevarthen, and Sperry, 1972) with patients whose two cerebral hemispheres had been disconnected surgically as treatment for epilepsy. Remarkable and unexpected behaviour was noted for these 'split-brain' persons. With the communication channels between the two hemispheres severed, these persons had two independently functioning hemispheres. Thus it was possible to explain the capabilities and limitations of each hemisphere. Through these carefully designed studies, Sperry (1964) was able to show that the right hemisphere could perform spatial tasks (draw a figure, recognize faces) but had virtually no language capability. On the other hand, the left hemisphere controlled speech, calculation, and reason but could not perform spatial tasks. The studies with split-brain persons stimulated interest in the hemispheric functioning of normal persons. Bogen (1977) on the basis of a review concludes:

1. There is an abundance of evidence (of which hemispherectomy is the most obvious) that one-half of the cerebrum (if it is a single hemisphere) can subserve the functions of a mind. Corresponding conclusions cannot be supported by removing the top, bottom, back, or front half of the cerebrum, rather than either the right half or the left half.
2. The split-brain phenomena (in many different species) show that an individual with two hemispheres can at times have two minds; this same conclusion cannot be supported by bisection of the cerebrum horizontally, coronally or diagonally rather than midsagittally.
3. That two hemispheres, in normal continuity, do support two minds most of the time is not proven, so far as I am

aware. How often and when do two hemispheres in continuity support two minds? How does an individual remain integrated when the cerebral commissures are cut? It is questions such as these that concern most of us who are familiar with the facts.

DICHOTIC LISTENING

The basic underlying assumption of all these techniques is that there exists contralaterality of hemispheric processing. Dichotic listening tasks refer to application of different stimuli (e.g. two different verbal messages) to both ears simultaneously to determine which hemisphere more effectively processes verbal messages. For example, sounds presented to the left ear are processed by the right hemisphere (Geldard, 1972). Such dichotic listening studies have consistently found a right ear advantage for linguistic stimuli and left ear for nonlinguistic stimuli (Geffner and Hachberg, 1971; Ingram, 1975; Kimura, 1967; Knox and Kimura, 1970; Shankweiler and Studdert-Kennedy, 1967; Springer and Gazzaniga, 1957). For example, Knox and Kimura (1970) found a left ear advantage for verbal sounds in a sample of five to eight-year-olds. Krashen (1975), however, provides a thorough review of dichotic listening research.

LATERAL EYE MOVEMENTS AND TACHISTOSCOPIC STUDIES

One of the methods that has been proposed as a means of observing hemispheric asymmetry in normal persons makes use of lateral eye movements (LEMs) (Baken, 1971; Gur, 1975; Schwartz, Davidson, and Maer, 1975). Lateral eye movement refers to the shifts in gaze to the right or left that occur when people engage in reflective thinking. During ongoing cognitive activity, shifts to the left are presumed to reflect right hemisphere dominance, and shifts to the right, left hemisphere predominance. Theoretical underpinnings for the hypothesized relationship between LEMs and hemispheric asymmetry have been offered (Kinsbourne, 1975), but the primary basis of assertion is empirical, that is, it is believed by many researchers that a pattern of evidence exists which is highly consistent with the hypothesis that direction of LEMs is a reflection of hemispheric asymmetry. For a critical review and further possibilities, Ehrlichman and Weinberg (1978) have provided many suggestions. Studies using the tachistoscopic technique have confirmed the specialization of the cerebral hemispheres; the right hemisphere being superior for processing spatial tasks and the left hemisphere for linguistic tasks (Hines, 1975; Kimura, 1967; Levy, Trevarthen, and Sperry, 1972; Marcel, Katz, and Smith, 1974; Yeni-Homshian, Isenberg, Goldberg, 1975).

REACTION TIME AND SODIUM AMYTAL

Two of the techniques which deserve attention in addition to the above are the use of reaction time and sodium amytal to study laterality. The reaction time of each hemisphere to different tasks has revealed the same pattern of specialization discovered in the split-brain patients (Filbey and Gazzaniga, 1969; Bowers and Heilman, 1975; Mckeever Huling, 1971). With sodium amytal, a single hemisphere can be anesthesized, leaving the other alert. Studies using this technique provide a strong evidence for left hemisphere control of speech (Branch, Milner, and Rasmussen, 1964; Bogen and Gordon, 1971; Wada and Rasmussen, 1960).

ELECTROENCEPHALOGRAPHY

The method of assessing hemispheric involvement which is currently receiving the most attention is Electroencephalography (EEG) analysis (Brown, 1977; Green, 1970; Ornstein, 1978). Although this is a relatively new technology in the study of hemispheric specialization, there is much work being done in this area (Ornstein and Galin, 1974; Galin and Ellis, 1975; Dilling, Wheatley, and Mitchell, 1979). Using the ratio of alpha band power from each hemisphere, Butler and Glass (1974) found the left (but not the right) hemisphere active in mental arithmetic. Recording from the temporal and parietal regions, Galin and Ornstein (1972, 1973), Doyle, Ornstein, and Galin (1974), and Galin and Ellis (1975) used EEG techniques to isolate hemisphere activitiy for logical and spatial tasks. Their findings match the pattern of specialization presented earlier. On the basis of his results Ornstein concluded that technical reading was processed primarily in the left hemisphere, since the EEG pattern indicated involvement of that hemisphere during the technical reading task. Reading of interesting prose involved both right and left hemisphere processing since both the left and the right hemispheres were determined to be actively involved from the EEG pattern.

In combination, as Rubenzer (1978) concludes on the basis of his review, these studies demonstrating lateralization involved nearly 1,600 subjects. Interestingly, the results derived from methods of investigation which might be considered less "direct" (non-medical non-intrusive) generally concur with the findings derived from more rigorous and empirical (medical-intrusive) experimental techniques. A table of studies is presented in the Appendix.

Bogen (1977), in an excellent discussion on the split-brain and hemispheric capabilities, quotes Communist, American, Dutch, Italian, British, and Commonwealth neuroscientists for their researches on split-brain, and finally concludes with a splendid review (Sperry, 1974):

> Although some authorities have been reluctant to credit the disconnected minor hemisphere even with being conscious, it is our own interpretation based on a large number and variety of nonverbal tests, that the minor hemisphere is indeed a conscious system in its own right, perceiving, thinking, remembering, reasoning, willing, and emoting, all at a characteristically human level, and that both the left and the right hemispheres may be conscious simultaneously in different, even in mutually conflicting, mental experiences that run along in parallel.

Left and Right of the Brain: Characterization Evidence

As indicated in the previous section, there is a long history of attempts to explain and define the duality of the brain. Bogen believes that the duality is one that has pervaded experience and philosophy throughout history, independently of any explicit association with the two sides of the brain. Bogen has described the nature of duality as has been understood in the East and the West. He finds many clues in oriental philosophy:

> It seems to me as reasonable to suppose that the pre-Confucian concept of Yang and Yin reflects a projection onto the surroundings, as to suppose that it is forced on thoughtful man by the external world. With respect to Vedanta, or Hindu thought, we are on slightly firmer ground. Akhilananda distinguishes intellect (*buddhi*) from mind (*manas*) and Professor Huston Smith has informed me that this distinction between buddhi and manas is common among Hindu psychologists. He pointed out further that this was once rendered into English by Radhakrishnan as "rational thought" and "integral thought". It seems that certain contemporary Western psychologists are converging towards the Vedantic view. . . .

Many writers have linked hemispheric asymmetry to fundamental dichotomies in philosophy and culture. This dichotomous nature of knowing, or two different "kinds of intelligence", or two different "sets of information-processing rules", have been labelled in different terms by scholars. That a wide spectrum of thinkers from religion to science to philosophy in different parts of the world have arrived at similar conclusions is indicated by the following listing in the table (Bogen, 1975).

TABLE: *A partial list of authors who have postulated two parallel "ways of knowing" or two "types of intelligence" or two "cognitive styles"*

Akhilananda	buddhi	manas
Assagioli	intellect	intuition
Austin	convergent	divergent
Bateson and Jackson	digital	analogic
Blackburn	intellectual	sensuous
Bronowski	deductive	imaginative
Bruner	rational	metaphoric
Cohen	analytic	relational
De Bono	vertical	horizontal
Deikman	active	receptive
Dieudonne	discrete	continuous
Freud	secondary	primary
Goldstein	abstract	concrete
Hilgard	realistic	impulsive
Hobbes (per Murphy)	directed	free
Humphrey and Zongwill	propositional	imaginative
W. James	differential	existential
A. Jensen	transformational	associative
Kagan and Moss	analytic	relational
D. Lee	lineal	nonlineal
Levi-Strauss	positive	mythic
Levy and Sperry	analytic	gestalt
Lomax and Berkowitz	differentiation	integration
Maslow	rational	intuitive
McFie, Piercy (from Spearmen)	relations	correlates
McKellar	realistic	autistic
Neisser	sequential	multiple
Oppenheimer	historical	timeless
Ornstein	analytic	holistic
Pavlov	second signalling	first signalling
C.S. Peirce	explicative	ampliative
Polanvi	explicit	tacit
Price	reductionist	compositionist
Radhakrishnan (per H. Smith)	rational	integral
Reusch	discursive	eidetic
Schopenhauer	objective	subjective
Sechenov (per Luria)	successive	simultaneous
G.S. Smith	atomistic	gross
Wells	hierarchical	heterarchical

The way in which modern split-brain research arrived at duality has been discussed in the previous section. The list of the studies related to the functional organization of the hemispheres has been included in the appendix. However, the qualities of the two sides or lobes as identified have been listed in the figure given on p. 18.

LEFT HEMISPHERE

Each cerebral hemisphere, as indicated earlier, is capable of functioning in a manner different from the other. For many years attention was focused on the hemisphere in which speech was localized, the so-called "dominant", "leading" or "major" hemisphere. It was hypothesized that this hemisphere was primarily responsible for the processing of language and planning, the two functions which clearly distinguished men from the rest of the animal kingdom (Bronowski, 1973). It has been found to be anatomically larger than the right hemisphere, as evidenced by neonatal studies (Geschwind, 1972). It is considered to be more active than the right hemisphere in most adults, as indicated by EEG analyses.

It is really only in the last decade that the extent of specialization in the so-called "minor" hemisphere has been studied rather extensively. Little neurological attention had hitherto been given to the right cerebral hemisphere. This historical oversight and neglect is largely because it is the left hemisphere (in most people) which does all the reading, working, calculating, and conventional thinking. The empirical evidence in support of the left hemisphere's involvement in language processing is substantial. Krashen (1975) presents the reasons:

1. Loss of speech caused by brain damage occurs far more frequently from left-sided lesions than from right-sided lesions (Russel and Espir, 1981).
2. When the left hemisphere is temporarily anesthetized, loss of speech results, but when the right hemisphere is anesthetized, this generally does not occur (Wada and Rusmussen, 1960).
3. When competing, simultaneous verbal material is presented to the two ears, a reliable right-ear advantage in

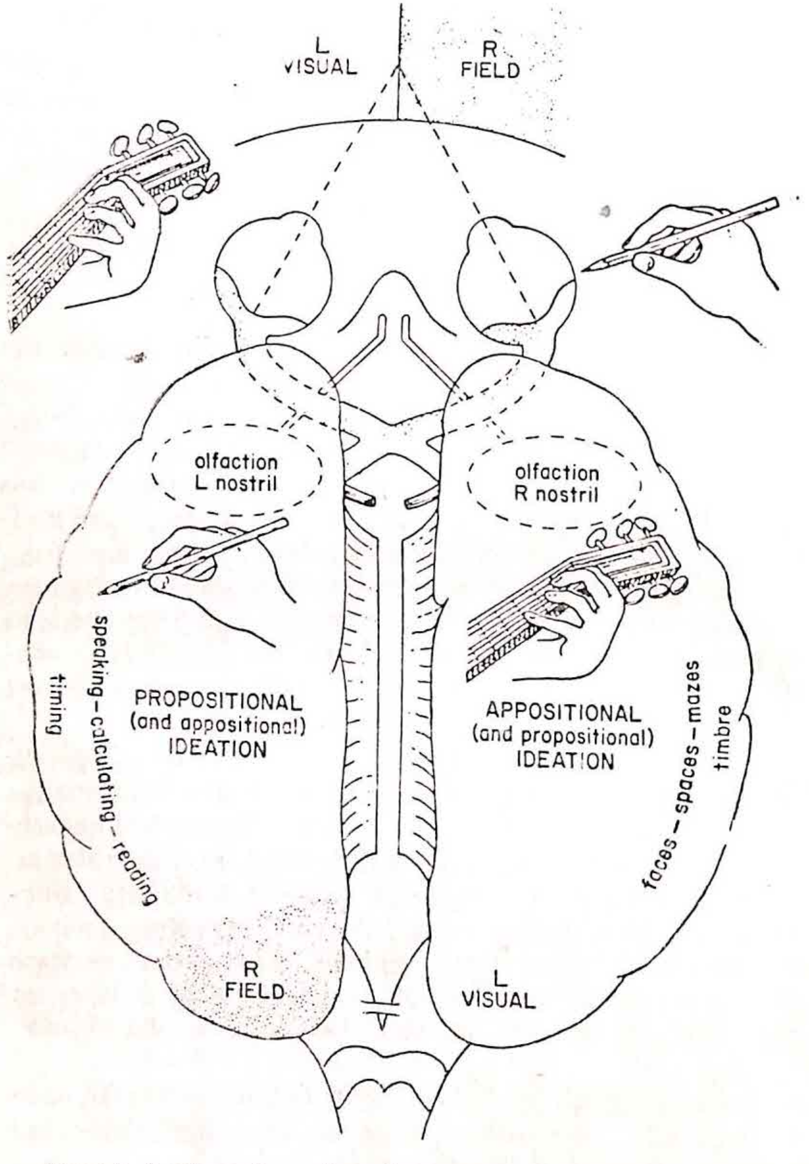

FIGURE: A schematic outline of the brain as seen from above, to suggest the complementary dominance of the cerebral hemispheres for various tasks, summarizing the evidence from cases of lateralized lesions and from testing of patients with cerebral commissurotomy. Based on version updated and redrawn (by J.E.B.) from the original conception of R.W. Sperry (Sperry, Vogel, and Bogen, 1970).

(*Reproduced by courtesy of Dr. J.E. Bogen*) response accuracy and reaction time is found, presumably a result of better right-ear connection to the left hemisphere (Kimura, 1961, 1967; Springer 1971).

4. When verbal material (or material easily coded into language) is presented to right- and left-visual fields, most subjects show a right-visual field superiority in response accuracy or reaction time, presumably due to better right-field connections to the left hemisphere.
5. During verbal tasks, whether performed overtly or covertly, increased alpha wave suppression and a greater evoked response is found over the left hemisphere (Robbins and McAdam, 1974).

That the left hemisphere alone processes verbal information may not be correct. It is not a simple case of suggesting that all aspects of language are processed by the left hemisphere, not that the functions of the left hemisphere are limited to language. It may be of interest to note that Goodglass and Quadfasal (1977) found that out of 123 left-handed subjects, only 53% were left-hemisphere-dominant for language processing, whereas in the other 47% the right hemisphere was predominantly utilized for language processing. The left hemisphere has also been found to be involved in comprehension and retention of language. Studies have also indicated that short-term memory, that is, the type of recall which enables conversational speech to occur through retention of what is being said in the immediate conversation, is primarily in the domain of left hemisphere.

There is conclusive evidence to believe that with respect to the expression of language through speech, it is exclusively processed in the left hemisphere (Burkland and Smith, 1977; Eccles, 1973; Sperry, 1974; Nebes, 1974).

There appears to be transference from left hemisphere processing to the right hemisphere processing in writing. Although the verbal aspect of writing is predominantly a function of the left hemisphere, the visual motor aspect of writing appears to be within the realm of the right hemisphere (Brandwein and Ornstein, 1977).

The left hemisphere is also involved in learning the 3 R's. Reading is considered to be principally a left hemisphere function (Hunter, 1976; Sperry, 1974). Mathematical functions, particularly calculations (Dumas and Olson, 1977) and algebra (Hunter, 1976) are postulated to be left-hemisphere operations. Writing papers requires cooperations from both hemispheres (Smith, 1972).

The left hemisphere is considered to be a rational-linear mind specializing in sequential processing, logical, analytical thinking (Brandwein and Ornstein, 1977; Salk, 1973) and verbalization. The left hemisphere is far more "constrained and it sifts through inputs and reduces functions to logical-rational forms and acts more like a digital computer (Samples, 1975). This is the mind that requires structure and order, which processes perception and sensory input in logical and linear modes. The acquisition of new habit patterns is also considered a left-hemisphere function (May, 1977). McFie and Piercy (1952) have proposed that the left hemisphere is well suited for the "education of relations" which is essentially the ability to analyse the common aspects of a task and formulate systematic relationships among these tasks.

To summarize, it may be safe to maintain that the study of the left hemisphere is thus beginning to extend beyond purely linguistic considerations—indeed, the rapidly increasing store of knowledge about the left hemisphere promises to make further contributions to the whole range of human behaviour (Krashen, 1975).

RIGHT HEMISPHERE

The other side of the brain—the right cerebral hemisphere, which controls the left side of the body, is called the minor, subordinate or mute side because it cannot verbalize what it knows. It was found by Geschwind (1970) to be anatomically smaller than the dominant or left hemisphere. Research has indicated that the right hemisphere has remained underestimated and even today neurophysiologists cling to the view that the right hemisphere is a mere unconscious automaton, while we live in left hemisphere.

Research reviewed by Rubenzer (1978) indicates that the right hemisphere is not totally silent. In fact, language function is somewhat more equally shared between the hemispheres before the age of five. Studies also indicate that the right hemisphere is capable of processing language if the discriminations are uncomplicated (e.g., a positive from a negative statement). The analysis of voice intonation, an integral component of language, appears to be a function of the right hemisphere (Van Lanker, 1975). The primary expressive mode of the right hemisphere is speculated to be metaphorical in nature (Eccles, 1973; Ornstein, 1972; Samples, 1975); however, in general the verbally communicative ability of the right hemisphere is relatively limited and dependent upon the left hemisphere.

The interpretation of complex visual patterns has been found by several investigators to be predominantly the right-hemisphere function. Further, the right hemisphere is much more adroit in the recognition of faces, while the left hemisphere remembers names that go with the faces. The retention of visual patterns, such as geometric designs and graphs, is believed to be in the domain of the right hemisphere (Hines, Sutker, Satz, and Altman, 1976). It is also contended that the iconic presentation of information (e.g., graphic displays, diagrams, flow charts, etc.) greatly facilitates both the comprehension and the retention of information, and that iconic memory is perimarily a function of the right hemisphere (Taylor, 1976). Perception and retention of complex nonverbal auditory patterns, such as music or Morse code occurs in the right hemisphere. Awareness of body position, spatial orientation, and the perception of fine and gross motor activities all come within the realm of the right hemisphere (Brandwein and Ornstein, 1977). Haptic or tactile perception is contended by Kimura (1973) to be a right-hemisphere function. Notwithstanding the caveats of making functional inferences on the basis of structural characteristics, the review of the differential neuroanatomy of the two hemispheres makes two hypothetical cognitive consequences plausible (Goldberg and Costa, 1981):

1. The right hemisphere has a greater neuronal capacity to deal with informational complexity.
2. The right hemisphere has a greater ability to process many modes of representation within a single cognitive task, while the left hemisphere is superior in tasks which require

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> fixation upon a single mode of representation or execution.

In summary, the right hemisphere is lateralized for multiple processing; it is spatial, holistic and simultaneous in nature (Bogen, 1975). It houses spatial perception, holistic understanding, perceptual insight, tactile sensation, musical ability, visualization and intuitive ability. Its mode is metaphoric, analogic and holistic. It also possesses visual acumen of the brain. This side of the brain thrives on multiple relationships processed simultaneously. In a simplistic way we could say that the right cerebral hemisphere remembers faces, while the left hemisphere remembers names (Samples, 1977). The functions of the right hemisphere have been described as creative (Bogen, 1969; Torrance, 1978) and divergent (Kinsbourne and Smith, 1974; Paronne and Pulvion, 1977). Growing awareness that the right hemisphere imagery is the source of creativity is an interdisciplinary phenomenon. A prestigious MIT Engineer, Prof. Stanley West (1975), observed:

> With support from recent research in the neurosciences I speculate that minor scientific creativity is likely to be mainly left hemisphere cognitive excitation, while major scientific creativity is likely to involve the excitation and intercommunication of both cerebral hemispheres. . . . In other words, some kind of altered state of awareness may be essential to creativity. . . . Creativity in many extraordinarily gifted individuals depends in part upon temporary dominance of the right cerebral hemisphere.

West then quotes his colleague, MIT Professor Weizenbaum (1978):

> The history of man's creativity is filled with stories of artists and scientists who after working hard and long on some difficult problem, consciously decide to "forget it, to, in effect, turn it over to their unconscious, i.e., to their RH (right hemisphere). After some time, often with great suddenness and totally unexpectedly, the solution to their

> problem announces itself to them in almost complete form. The RH appears to have been able to overcome the most difficult logical and systematic problems by, we would conjecture, relaxing the rigid standards of thought of the LH. Given the looser standards the RH employs, it was perhaps able to design thought experiments which the LH simply could not, because of its rigidity, conceive. The RH is thus able to hit upon solutions which could then, of course, be recast into strictly logical terms by the LH.

The RH processing mode is also hypothesized to be prevalent according to the findings of Hadamard (1945) and Hebb (1966) when aesthetic judgement is required in task.

It is evident that the right cerebral hemisphere makes an important contribution to human performance. It is the neural basis of our ability to take in fragmentary sensory information and from it construct a coherent outside world—a sort of cognitive spatial map within which we plan our actions. Robert Nebes (1975) who has made studies in this field concludes: Given the results to date of hemispheric specialization, it seems natural to many researcher in related fields that the scientific and technological aspects of our civilization are products of the left hemisphere, while the mystical and humanistic aspects are products of the right. The right hemisphere thus has been enthusiastically embraced by counter-culture groups as "their side" of the brain. They see in it the antithesis to an upright technological Western society, identifying its synthetic abilities with Eastern mystics' view of the interrelationship of all things (Ornstein, 1972). How well such a grafting of philosophy onto anatomy will survive is unclear, but certainly right-hemisphere attributes will continue to be explored in the coming years, and their role in the various phases of human life examined.

CONCLUSION

The study of hemispheric differences also suggests that both these modes of consciousness and cognitive style which can be considered in terms of process specificity, complement each other in promoting specific behaviour. As Nebes indicated, the human cerebral cortex and its diverse hemispheric functions clearly form an integrated whole (Nebes, 1975). In fact, Piercy (1976) outlined six functionally different forms of inter-hemispheric organization demonstrating the cerebral organization as the basis for processing information, and constructing expressive behaviour must be understood as more than simple lateralization of cerebral functions. Cerebral organization must also be interpreted in terms of inter-hemispheric integration, or, in Bogen *et al.'s* (1972) term, cerebral complementarity. Findings have shown that the right hemispheric functions, perceptual in nature, are important factors contributing to letter recognition and are necessary in the processing of verbal as well as nonverbal information; support for these notions comes from Levy's (1976) postulate of a leftward perceptual bias. The implication is that hemispheric contributions as well as unique functions derived from hemispheric asymmetry are crucial to the successful and complete processing of information (Zalma, Reynolds, and Kaufman, 1977). It is, therefore, desirable and important to stimulate both the hemispheres. Unbalanced emphasis on the precocious attainment of a talent early in a child's life may have permanent effects on his/her emotional and cognitive development. Integrated development will go a long way in helping man in actualizing the highest and the most creative visions.

Inadequacy of Current Education: Discrimination against Brain

Though there are many remaining uncertainties, as neurosurgeons do concur, studies in the field of 'hemispherical specialization have created a certain uneasiness in behavioural,social, and educational sciences. These studies indicate that education as it is structured in most of our schools today develops only a part of the human brain and leaves half of an individual's high level potential unschooled. Since education, as Bogen (1975) maintains, is effective only in so far as it affects the working of the brain, we see that most currently prevailing patterns of education unrealistically and harmfully are heavily biased towards left cerebral functioning and are antithetical to right cerebral functioning and in the process leave the other side less developed. Schools have traditionally been very much concerned with what Suzanne Langer has called "discursive thought" and denotative symbols. Pupils have been taught to define words precisely, to operate mathematical processes correctly, to reason logically, and neglect some of the oldest and most fundamental processes of the mind, those which Langer calls "presentational" or "expressive". Beneath the superficial, rational, and technological mechanisms of our civilization lie strings of another sort. Biologically grounded, they precede the patterns of any particular culture. Fromm has referred to the unconscious symbolism of drama and fantasy as the "forgotten language". Schools are now busy teaching many languages, the vocabulary of each science, the symbols and formulae of mathematics, ignoring the "forgotton language" which incidentally is, perhaps, more vital than any of the denotative systems. Given a curriculum composed so largely of "facts" we impoverish the learner's experience and foster a shallow form of competence. The assumption that rational-cognitive information is the only good information is built on an inaccurate perception of human behaviour. This is an incredible state of things, for we know well, both through years of research and common experience, that there are other kinds of relevant information that affect our thoughts and behaviour—intuition, unconscious and preconscious processes, feelings, extrasensory perception as well as spiritual and mystical experiences. All these elements, when fused together, make it possible to act as full human beings. Modern education, instead, has unrealistically fragmented men's living and learning processes and, worse, has chosen to emphasize only one part of an immensely complex human process.

The societal danger of this monomania of the rational can be well documented (Nakata, 1972). "There is a horrible example in history of what Educated Society might easily become unless the university commits itself to the education of the whole man. It is the destruction of one of the world's greatest and most creative civilizations, the China of the T'ang and Sang period, by the imposition of a purely verbal, purely intellectual, purely analytical education on man and society. . . . This commitment to the purely intellectual in man destroyed what had been the world's leader in art as well as in science, in technology as well as in philosophy. We are today in a similar danger—for we tend, under the impact of the triumphs of organization and the analytical mind, to downgrade everything that is direct, immediate, and not verbal (Drucker, 1965). Riesman, therefore, also voiced this concern when he maintained that the arts have been given short shrift. "This is a verbal culture that puts a premium on the highly articulate. Our oral acuity is keen, but our visual acuity in dim. Students should be more aware of their spatial environment." (Schiefelbein, 1980). Reading, writing, and arithmetic which are mostly emphasized are all logical-linear processes, and for most of us are fed into the brain through our right hand. Other vital processes are neglected and overlooked. Most educational policies have tended to aggravate and prolong this one-sidedness. There is a kind of damping down of fantasy, imagination, visualization, clever guessing and divergent thinking in the interests of rote-learning, reading, writing and arithmetic. Great emphasis is being placed on one's being able to say what one has on one's mind clearly and precisely the first time. The atmosphere emphasizes intraverbal skills—"using words to talk about words that refer to still other words" (Bruner, 1974). Our society's overemphasis on "propositionality" at the cost of the "appositionality" does not only result in adjustment difficulties but also in lopsided education for entire student body. Our students are not being offered the education they require to understand the complex nature of the world and themselves, an education for the whole brain. Sperry (1975) wrote:

> Our education system and modern society generally (with its very heavy emphasis on communication and on early training in the three R's) discriminates against one whole half of the brain. I refer, of course, to the nonverbal, nonmathematical, minor hemisphere, which we find has its own perceptual, mechanical and spatial mode of apprehension and reasoning. In our present school system, the attention given to the minor hemisphere of the brain is minimal compared with the training lavished on the left, or major hemisphere.

This issue can be considered from another perspective (Bogen, 1975). It is likely that some anatomical asymmetry underlies the potential for hemisphere specialization, but it is also clear that the extent to which capacities are developed is dependent upon environmental exposure. Although humans of any culture, so far as we know, have the potential for reading and writing, many remain nonliterate and thus fall short of acquiring the most special of left-hemisphere functions. Conversely, we can readily comprehend the concept of a society in which "right-hemisphere illiteracy" is the rule. Indeed, our own society (admittedly complex) seem to be, in some respects, a good example: a scholasticized, post-Gutenberg industrialized computer-happy exaggeration of the Graeco-Roman penchant for propositionizing. In a review of hemispheric specialization, Sperry (1973) again wrote:

> The main theme to emerge from the foregoing fact is that there appear to be two modes of thinking, verbal and nonverbal, represented rather separately in left and right hemispheres, respectively, and that our educational

> system, as well as science in general, tends to neglect the nonverbal form of intellect. What it comes down to is that modern society discriminates against the right hemisphere.

Education has also played havoc with any attempt to generate and pursue new values other than those embedded in a scientific, technological world. As Joseph Weizenbaum has argued in his book *Computer Power and Human Reason, From Judgement to Calculation* (1976), a work that deserves the serious attention of everyone concerned with education: Today education encourages epistemological narrowing with a vengeance and with the most dire results. Weizenbaum speaks of "the imperialism of instrumental reason" in describing the strong current tendency to identify reason with the narrowest sort of instrumental logic, to exclude the emotions, the will, and intuitive insights from the domain of rationality, and to reduce all human problems to their lowest elements in order that their narrow view of reason can be applied to them, whatever the consequences for human wholeness doing so might entail.

Excessive emphasis on the process of technical rationalism, technocratic pragmatism, testable cognitive skills (scholarship), instrumental reason and the regarding of intuitive and imaginative insight as secondary to instrumental reason, and the acceptance of the validity of technological solutions to all human problems as established and beyond challenge—makes educators and those involved in education find themselves in much the same plight as Bellow's and Barfield's artists. Such a philosophy of education usually becomes analytical, more interested in the logic of propositions than in existential issues, which accounts for its glacial, sterile character in recent years—likened by more than one critic to a diet of disinfectant (Richmond, 1975). This process of epistemological narrowing has led to an even further shrinkage of values—to the point that ideas are conceived as little more than, to use George Kelly's (1963) phrase, "conceptual particles", to be pushed and pulled about, interchanged, manipulated and discarded, as need may be. That this view conceals a deep and radical anti-intellectualism in any traditional sense of the term is evident.

Educational institutions in placing a premium on verbal/numerical categories have systematically eliminated those experiences that would assist young children's development of visualization, imagination and or sensory/perceptual abilities. The over-analytical models so often presented to children in their textbooks emphasize linear thought processes and discourage intuitivity, analogical and metaphorical thinking. These factors of neural functioning among children have been left to modification by random environmental rather than systematic institutional means. Little use is made of natural curiosity and creativity, the desire for exploration, novelty, and surprise, and the child's inherent pleasures in activity and function. These realities of childhood, these fascinating strengths of the young learner are drained away, forgetting the conception of John Fisks that advance in civilization is an accomplishment of the prolongation of infancy. As McLuhn (1962) says (for once, the pun is unintentional!): "It is, indeed, the homogenizing hopper into which we toss our integral tots for processing." The subjective happenings within the raw, concrete and aesthetic experiences are sacrificed for some other premature facility and glibness. John Dewey (1941) made a significant observation many years ago:

> To require a child to turn away from the rich material which is all about him, to which he spontaneously attends, and which is his natural, unconscious food, is to compel the premature use of analytic and abstract powers. It is willfully to deprive the child of that synthetic life, that unconscious union with his environment, which is his birthright and privilege. There is every reason to suppose that a premature demand upon the abstract intellectual capacity stands in its own way. We are not yet in a position to know how much of the inertia and seeming paralysis of mental powers in the later periods is the direct outcome of excessive and too early appeal to isolated intellectual capacity.

Discouraging sensory, imaginative behaviour in favour of verbal, numerical skills, valuing absorption of inputs of linear data, considering the child's touching, giggling, talking, and examining the surroundings, falling into fantasy, day-dreaming, and differentiated imaginations as deviance does not help develop spatial, perceptual and abstract abilities which account for approximately three-fifths of the behaviour measured by standard intelligence tests. The present mechanistic paradigm shaped by the world-machine images of Newtonian "Law" minimizes the meaning of those organic things that we like to do most: singing, dancing, eating, making love, sleeping, and so on. From the vantage point of organic integration, those same concerns emerge as central, vital to social and educational reforms (Hawkes, 1974). All this affirms that our system of education is one which leads to the underdevelopment of the functions of the right hemisphere.

In the curriculum as well, the excessive emphasis on intellectualizing, verbalizing, analysing and conceptualizing processes has led to ignoring the question of what it is the learner must do to acquire, create, organize and discover knowledge. This obviously imposes neurotogenic limitations and binds mental processes so tightly that they impede the perception of new data. It promotes functional fixations, insulates the mind against discoveries, and ultimately drives out creative thinking (Szilak, 1976). In the words of Bogen, a neurosurgeon, the curriculum is ' inordinately skewed to reward only one part of the human brain leaving half an individual's potential unschooled" (Bogen, 1975). The traditional preoccupation with formal intellectual education effectively blocks the possibility for the students to recognize and cultivate creativity, transcendence and immanence.

The educational methodology usually followed has "overemphasized the values of an analytical attitude or even of rationality". We have become so analytical that we even analyse the capacity to analyse. In the words of Neol McInnis:

> Our present teaching methods, at all levels of education, tend to foster common intellectual skill: thinking the world to pieces. This skill is very essential. But thinking the world to pieces is only half of understanding. . . .

> Having been taught mostly to think the world to pieces, is it any wonder that we are now tearing it to pieces?

Analysis is not intrinsically damaging, but a purely analytical view of the world and self is a terrifying dead end, for, by its own definition, it excludes the mystical, tragic, spiritual, personal, playful, organic, and prophetic dimensions of life. Such an analytically educated man who is partly 'cultured' gets lost in his own power to understand almost everything and believes in almost nothing. T.S. Eliot's "The Love Song of J. Alfred Prufrock" tells about him. He was lost in a vision of the world of parts and at best made wild guesses about any Whole or Wholes. He was virtually paralyzed in the face of action:

> Do I dare
> Disturb the universe?
> In a minute there is a time
> For decisions and revisions which
>   a minute will reverse.

Livingston's (1952) estimation of 'analysis' as an educational objective is interesting. Analysis, according to him, deludes us into thinking that we know all about thingswhose inner reality we miss. The habit of analysis accustoms us to be content with a view of the world which seems incomplete and is not. The spirit of analysis, uncorrected, fosters weakness and impoverishes the mind. "To teach people to see and feel is a more important skill. By overstressing the critical attitude one may produce characters—they are not uncommon—both superficial and satisfied with their superficiality."

The above discussion suggests that educational theory needs to be freed from the stranglehold exerted by archaic modes of thought and the vested interests of a guild of pedagogues who decide what counts as learning, knowledge, and education. It also suggests a shift in objectives, methodology, and evaluation. The fundamental change of premises in our understanding of knowing and in our sense of world will require an unrelenting questioning of the unexamined presupposition and assumption about reality that pervade our classrooms, textbooks, and media. The Charles F. Kettering Foundation symposium held in 1980 at Woodstock, Vermont, on "Knowledge, Education, and Human Values: Towards the Recovery of Wholeness", attended by participants with extensive background in the sciences including neurophysiology, medicine, quantum-physics, cellbiology, computer science, philosophy, sociology, anthropology and government, was a beginning effort to chart the possibility of the transformation in our ways of knowing and "the innumerable implications" for our earth, our culture, our education (Sloan, 1981).

We have to seek a new paradigm which somehow integrates nebulous, illusive metaknowledge with the more rigorous, empirical and analytical methods with which we are so familiar. In the words of Brown (1978):

> What seems obvious is that for a person to function with his whole brain he must himself be a whole person, someone who is personally sound, who has integrated his feelings and intellect within himself with the world around him, who can accept new data without threat or over-eagerness, who is concerned with his process as well as the process of institutions and communities, and who sees process as a goal. I believe there are many cues here and I hope that we will not only get assistance in our quest from the formal philosophers, but also from the philosopher within each of us.

Curriculum, Forms of Knowing and Wholeness

Research on split-brain suggests that the curriculum, which in the final analysis represents the core, the tactile centre of the educational enterprise (Whitefield, 1971), has to be planned in such a way that the endless opportunities for a balance between the right hemisphere's spatial-synthetical modality and the left hemisphere's verbal-analytical modality is maintained. Learning experiences should be characterized by openness and comprehensiveness and should create a new desire for knowledge and provide the learner with skills which will enable him to translate curiosity into action. The curriculum should enhance sensory awareness for exploring non-rational ways of knowing. Any activity which is intentional, like the curriculum, should be based for its maximum effectiveness upon the analyses of the nature of knowledge and inherent human abilities. The demarcation of knowledge by Phenix (1964) suggests a useful pattern for general education. The analyses by him suggest that the full development of human beings requires education in a variety of realms of meaning rather than in a single type of rationality. To him education and the curriculum are primarily concerned with "engendering essential meanings". He argues that human beings have the power to grasp meanings from their experiences through conceptual understandings and that the ideal life is one of a pattern of meanings. For Phenix, rationality as the distinguishing feature of man is important, but insufficient because of its apparently excessive emphasis on logical cognitive behaviours at the possible expense of the emotions, creativity and conscience which are far from being entirely cognitive, i.e., ultimately describable purely in terms of language and symbol.

The life of meaning is far better served by using materials that tap the deeper levels of experience. Such materials reveal new perspectives on old problems, by throwing familiar experiences into fresh combinations and showing old beliefs in novel contexts. Such imaginative use of materials generates habits of thought that enable the students to respond to rapid changes in knowledge and belief with zest instead of dismay and to experience joy in understanding rather than the dead weight of ideas to be absorbed and stored. Phenix's scheme of the logical classification of meanings which is presented in a table below suggests that the curriculum should at least provide for learning in all the six realms of meanings: symbolics, empirics, synnoetics, aesthetics, ethics, and synoptics. Without these, as Phenix (1964) observed, a person cannot realize his essential humanness. If any of these is missing, the person lacks a basic ingredient in experience. They are to the fulfilment of human meanings something like what basic nutrients are to the health of an organism. Each makes possible a particular mode of functioning without which the person

Logical classification of meanings

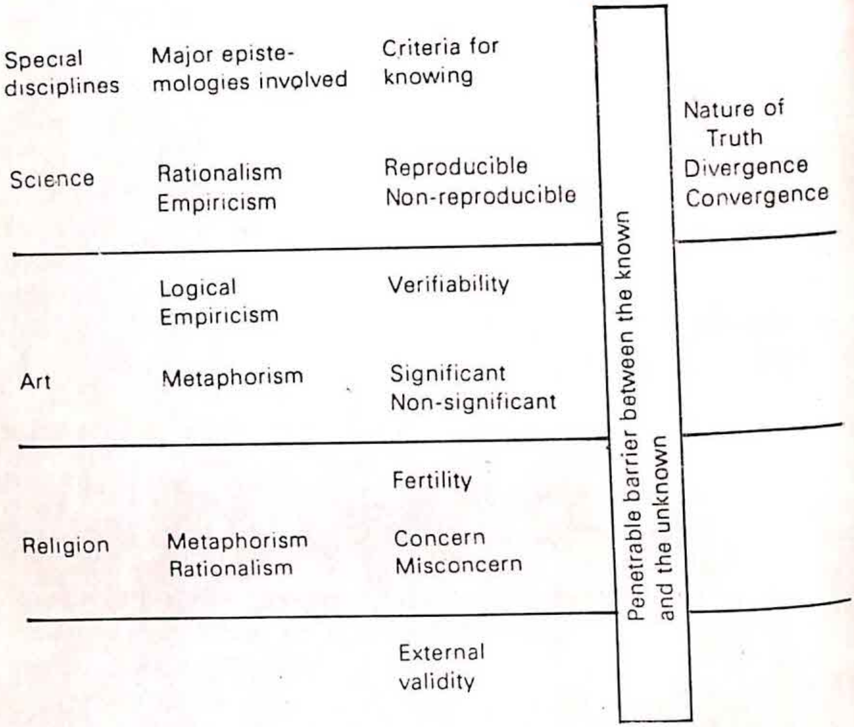
Generic classes		Realms of meaning	Disciplines
Quantity	Quality		
General	Form	Symbolics	Ordinary language, mathematics, nondiscursive symbolic.
General	Fact	Empirics	Physical sciences, life sciences, psychology, social sciences.
Singular	Form	Aesthetics	Musical, visual arts, arts of movement, literature.
Singular	Fact	Synnoetics	Philosophy, psychology, literature, religion in their existent aspects.
Singular	Norm	Ethics	The varied special areas of moral and ethical concern.
General	Norm		
Comprehensive	Fact	Synoptics	History, religion, philosophy.
Comprehensive	Fact		
Comprehensive	Norm		

cannot live according to his own true nature. Phenix's schemes of curriculum has the potentiality for stimulating both the left and the right hemispheres. It is this that makes us recognize the need for content, method, and materials that will utilize the right brain in an equally vigorous manner (Ornstein, 1977).

Research indicates that hemispheric specialization tends to be process specific, but it does not underestimate the importance of the subject matter. Subject matter, as Bogen (1975) believes, *does* make a difference. Although any pursuit is probably bihemispheric in some degree, the relative hemispheric participation obviously varies considerably. This indicates the need for considering a revised concept of the basic paths of knowledge. A scheme (Royce, 1970) of the paths of knowledge suggests that such paths are varied and diverse.

Curriculum needs to reflect and in turn be developed, keeping in view various images of reality. Royce has developed this theme at some length in a book under the title *The Encapsulated Man* (1964). The assertion made is that men of different philosophic commitments (i.e., world views) reflect limited particular epistemological profiles. This state of affairs is particularly apparent if we look at specialists in contrasting disciplines of knowledge, such as indicated in the figure given on page 36.

It may be noted that all three epistemologies are involved in each of the three representative disciplines of knowledge, but it is also clear that each discipline gives greater credence to one or more of them. The scientist, for example, "thinks", "intuits", "symbolizes" and "senses" as a scientist, but he maximizes the rational and the empirical ways of knowing and minimizes the symbolic and the intuitive processes at the expense of the thinking and the sensory processes. There are, of course, wide variations in the possible permutations and combinations of epistemological profiles, and this brief exposition should be taken as selective and typical rather than as absolute and general (Royce, 1964). This epistemological classification suggests that the curriculum, in order to reflect representative disciplines of knowledge, should include various modes of knowing, ideation and images of reality. Therefore, curriculum should be considered as a fluid laboratory of resources providing for various paths of knowledge. The



Special disciplines	Major epistemologies involved	Criteria for knowing	Penetrable barrier between the known and the unknown	Nature of Truth
Science	Rationalism Empiricism	Reproducible Non-reproducible		Divergence Convergence
	Logical Empiricism	Verifiability		
Art	Metaphorism	Significant Non-significant		
		Fertility		
Religion	Metaphorism Rationalism	Concern Misconcern		
		External validity		

FIGURE: Representative special disciplines of knowledge

learner may draw what he needs without any senseless restrictions being placed upon him because of age or grade level. Faith should also be placed in what the late Jules Henry once referred to learning as "polyphasic" by which he meant that human beings have a strong innate tendency to learn more than one thing at a time. This will help in meaning generation and developing various modes of ideation.

Hemispheric specialization research suggests, as does Broudy (1972), that the reform of the educational system, or the system of schooling can be viewed more profitably as the redistribution of didactics, philetics and heuristics in the various segments of the system rather than as a battle between the bad guys of the old establishment and the white knights of counter-culture. It is possible that through initiation into the realms of meaning by appropriate choices of disciplines, may result the balanced development of cerebral hemispheres in a person. Such a 'complete person' appears as one skilled in the use of speech, symbol and gesture, well informed and capable of creating and appreciating objects of aesthetic interest, endowed with a rich and disciplined life in relation to self and others, able to make wise decisions, to judge between right and wrong and possessed of an integral outlook (Phenix, 1964). As Yuonne Artand (Srinivas Iyengar, 1974) puts it brilliantly in the essay "Education Unlimited":

> And this study will not separate inner knowledge from knowledge of the world, but will consider as self-knowledge, knowing how to dance, to play an instrument, to repair an automobile, to talk to an animal, or to programme a computer. When man becomes able to govern himself he will naturally discover that the universe also is self-governing. For if yoga is the knowledge of the cybernetics of man, science is the knowledge of the cybernetics of the universe. These two bodies of knowledge form a single whole and evolve together.

The best approach to mathematics, physics, chemistry, biology, history, sociology, poetry, music, art is to see them all as petals of one flower, notes of a single piece of music, tints of the same apocalyptic rainbow arc, rays that feel the same central illumination (Srinivas Iyengar, 1974). In fact, a sense of the unity of the truths would contribute to the reconciliation of the various branches of knowledge, thus leading to the harmony of science, philosophy, technology and fine arts. In the spiritual or yogic vision, there is an automatic perception of this unity, and in the teaching of the various subjects the teacher can always direct the students to this unity. In the words of Sri Aurobindo (Joshi, 1974):

> The Yogin's aim in the sciences that make for knowledge should be to discover and understand the workings of the Divine Consciousness—Puissance in man and creatures and things and forces, her creative significance, her execution of the mysteries, the symbols in which she arranges the manifestation. The Yogin's aim in the

> practical sciences, whether mental and physical or occult and psychic, should be to enter into the ways of the Divine and his processes, to know the materials and means for the work given to us so that we may use that knowledge for a conscious and faultless expression of the spirit's mastery, joy and self-fulfilment. The Yogin's aim in the Arts should not be a mere aesthetic, mental or vital gratification, but, seeing the Divine everywhere, worshipping it with a revelation of the meaning of its works, to express that One Divine in gods and men and creatures and objects. The theory that sees an intimate connection between religious aspiration and truest and greatest Art is in essence right; but we must substitute for the mixed and doubtful religious motive a spiritual aspiration, vision interpreting experience.

To be educated one must be able to participate in the great human traditions of critico-creative thought: science, history, literature, philosophy, technology and to participate in the traditions one must first be instructed to learn a discipline. One has to be 'initiated', to use Richard Peter's (1963) language. One cannot always pay homage to the over-simplification of Snow's simple division of knowledge into the two cultures of arts and science. Schwab expanded Snow's categories to three: the investigative disciplines (natural science), the appreciative disciplines (arts), and the decisive disciplines (social science), while Peterson suggested four distinctive 'modes of thinking' or 'categories of mental experience' derived from knowledge, thus indicating the link between knowledge and human behaviour. These disciplines of knowledge with their own epistemologies have to be offered to develop neural symmetry.

A curriculum cut out rigidly and fixed uniformly for all, offering a mishmash of courses without any genuinely unifying principle, is like a heavy chain that smothers the innate tendencies of curiosity, variation, digression, play and spontaneity. It also cuts across a genuine development towards the synthesis and the globality of a wide sweep of integral comprehension. In actual operation of the educational process, there have to be what may be called 'evolutionary' syllabi.

It should grow according to the needs of the inner growth of the students; and the student should be free to develop and weave the various elements of his studies into a complex harmonious whole for the inner flowering of his personality. Here the split-brain research has great relevance and points to certain interesting possibilities. Gazzaniga (1975) points out: Indeed, one of the intriguing possibilities deriving from split-brain research is the possibility that man can be explicitly specialized in a variety of aspects of mental life: Superiority in the verbal area might not necessarily mean superiority in visual-spatial area, while the reverse may also hold true. If this proves correct, it may well follow that a particular child might be able to solve a problem using verbal symbols with greater ease than using visual-spatial ones, while another child might be better off solving the same problem using visual-spatial relations. The motivational aspect of this observation cannot, of course, be overemphasized. When a child's talents lie in visual-spatial relations and he/she is being forced into a curriculum that emphasizes the verbal articulatory mode of solving a conceptual problem, this child will encounter enormous frustration and difficulty which may well result in hostility toward the teacher and, worse, toward the learning process itself. If the teachers were to be made aware that the child is specialized in visual-spatial skills and the same conceptual problem is introduced, both discouragement and the subsequent hostility might be avoided if the child is allowed to use his special talents. Conversely, the child with high verbal skills may quite frequently be unable to visualize the spatial aspects of an assigned task; in this case also, far better results could be obtained if he/she is not forced into academic areas for which he/she is not naturally equipped.

A curriculum should broadly present areas of study which will bring the spirit in touch with values and develop habits of mind which analysis does not develop, and let the students pursue their studies in the way which will develop these qualities. Some subjects lend themselves more easily to analysis and so tend to draw the mind in that direction. Others are more richly charged with values. Pre-eminent among such subjects are art, music, poetry—not that these are the only subjects which will serve the purpose, but that in them we are compelled to feel rather than to think, to be receptive rather than critical. They stimulate and develop our power of feeling which Wordsworth calls the 'creative soul'. These subjects are of immense worth. They provide necessary material for a philosophy of life which is integral and integrating. That is essential for Purna Vidya. "Exceeding the dichotomies, Purna Vidya or integral education will seize wholeness by the centre, mobilize the diverse faculties and powers and team them together into a life-long sadhana of continuous aspiration and effort and extension of consciousness" (Srinivas Iyengar, 1974). Attempts to develop curriculum along these lines have been made (Brandwein, 1969). The scheme on pages 41-43 is interesting and useful.

The curriculum should reflect the institutional policy which Stuart Miller emphasized to be characterized by support for learning for love, for enhancing sensory awareness, for exploring non-rational ways of knowing. These activities must be integrated with the present highly rational and analytical courses of study. No one can give what he does not have: a teaching staff of one-dimensional men cannot teach rounding youngsters how to be properly round. What is needed is that the curriculum should provide the widest variability, honestly realized and recognized. "It may be principal virtue of these more recent findings about the brain, not only to serve as a scientific support for a more diversified curriculum, and not only to provide some direction for diversification but also to stimulate new sets of questions for those who will pilot the future of education." (Bogen, 1975).

A structure for a curriculum in the humanities for the elementary school

Probes into the meaning of truth, beauty, justice, love, faith, and their expression and communication	Level 6	Individuals perceive, create, and seek to convey the idea of valid world (with its elements of empirical and non-empirical reality).	Individuals create beauty.	Individuals create an environment.	Individuals celebrate acts of devotion and loving kindness.	Individuals commit themselves to an area of ultimate concern.	Level 6
	Level 5	Individuals attempt to verify (test) experience.	Individuals define objects and events in terms that satisfy their images of beauty.	Individuals codify the ideals of justice.	Individuals seek out and disseminate the heroic images of love of mankind.	Individuals attempt to explain the unexplainable.	Level 5
	Level 4	Individuals respond realistically to the environment, modifying it	Individuals re-create images of their experience.	Individuals celebrate the validity of human plurality.	Individuals express emotions that satisfy the varieties of affection.	Individuals celebrate acts of faith.	Level 4

(*Contd.*)

		to meet their expectations.					
	Level 3	Individuals attempt to portray a valid image of the environment.	Individuals express reaction to experience through objects and events they create.	Individuals seek out objects and events that symbolize justice.	Individuals seek out environments that promote kindness.	Individuals express humility as they develop awareness of the vastness of the universe.	Level 3
The conceptual rubicon		Man searches for and expresses the reality of his experience.	Individuals perceive and express the beauty of experience.	Individuals seek and express the ideals of justice.	Individuals seek and express love.	Individuals seek and express their faith.	
		TRUTH (Consistency, relevance, reality)	BEAUTY (Significant form, ideal form)	JUSTICE (Compassion, mercy)	LOVE (Loving-kindness)	FAITH (Ultimate concern, commitment)	

Probes into modes of expression and communication of experience	Level 2	Individuals make images and objects that interpret their response to the environment.	Individuals express experience and a response to the environment through body movements that imitate movement in nature.	Through play and drama individuals take on roles characteristic of the group and of folk heroes.	Individuals and groups express their experience and a response to the environment through imitation of sounds and rhythms.	Individuals express experience and a response to the environment through verbal statements and rhythms.	Level 2
	Level 1	Individuals create images and objects to portray their view of the world.	Individuals express feeling and through rhythmic body movement.	Through play and drama interpret experience.	Individuals interpret through sound and music.	Individuals interpret through written word.	Level 1
(Knowing and feeling)		ART	MOVEMENT AND DANCE	PLAY AND DRAMA	MUSIC	LANGUAGE	

Man has utilized the symbolic and oral traditions to express and communicate his experience.

OVERARCHING COGNITIVE–AFFECTIVE SCHEME

Art, Music and Dance: Toward Developing Learning Pores

Recent neurophysiological findings suggest that for a proper and balanced development different forms of knowing or awareness, which may be called as intuitive and articulated, or, if we prefer, existential and conceptual, need to be mastered. To be fully human we need to emphasize both kinds or modes of knowing. Gregory Kepes in *Language of Vision* states that the arts should live in inseparable unity with human life. Clearly, Kepes meant that for the fully functioning person to exist, the neural functions residing in both hemispheres of the brain need to be unified. Many educators have therefore intuitively recognized the need for more creative and artistic activity in the general school system.

John Blackie writes in *Inside the Primary School* that everything that we know about human beings generally and children in particular points to the importance of arts in education. They are the language of a whole range of human experience and to neglect them is to neglect ourselves. The Plowden Committee was even more explicit: Art is both a form of communication and a means of expression of feelings which ought to permeate the whole curriculum and life of the school. Arnheim (1969) has written for years about ways of perceiving and thinking that are visual and are different from, and complementary to, the verbal and mathematical modes traditionally emphasized in the academic environment. Art in the school programme offers the means of knowing, neglected by the rest of the school curriculum. Writing from the point of view of how painting can contribute to cognitive development, Eisner (1979) maintained:

> Perhaps the first thing that very young children learn is something that we often take for granted, namely they learn that they can, in fact, create images with material

> and that the activity of making such images can provide intrinsic forms of satisfaction. Knowledge that a person can alter the world through his or her own action is not something that is incarcerated in the cortex prior to birth; such knowledge grows from experience. The making of a mark on a paper or on wet sand or in moist clay is an alteration of the world, the forming of a new entity. When children are first given an opportunity to use materials this is one of the first things they learn, namely that their actions can have consequences. Furthermore, the action that brought about those consequences can themselves provide a source of satisfaction. The realization that actions can lead to consequences is what DeCharms calls "personal causation". Developing a sense of personal causation is not trivial, it represents a disposition towards the world, one that says that "I can make things occur, I am not simply at the mercy of the environment." The satisfaction that is received from action is what Charlotte Buhler refers to as function pleasure. . . . Art, like other fields within the curriculum, provides one of culture's potent symbol systems and enables children to create unique forms of meaning from experience. In the course of developing competence in this symbol system, children learn much more than we intend.

Since research evidence from hemispheric specialization suggests that one hemisphere of the brain processes information of a kind long associated with art, obviously education in art will preserve organic wholeness of man and of his mental faculties. "No subject" (except art), as Read puts it, "is capable of giving the child . . . a consciousness in which image and concept, sensation and thought are correlated and unified."

The Rockfeller Report on *Coming to Our Senses: The Significance of the Arts for American Education* (1977) supports the concept of "basic education" and maintains that the arts, properly taught, are basic to individual development since they, more than any other subject, awaken all the senses—the learning pores. "We endorse a curriculum which puts "basics" first, because the arts are basic, right at the heart of the matter. And we suggest not that reading be replaced by arts but that the concept of literacy be expanded beyond word skills.'' The report asserts that *learning about* arts is learning about the rich world of sensation, emotion and personal expression surrounding us each day. It claims that learning through art has the potential to enhance one's general motivation to learn and to develop one's respect for a disciplined approach to learning. Therefore, it cannot be argued that the arts hold second place to any other discipline of learning in heightening perception, sharpening the intellect, and strengthening conviction. The qualities that the arts offer to education are unique, they exist in no other discipline.

It is in the light of these that Bogen (1975) maintained, while writing a foreword to D. Friend's *Composition: A Painter's Guide to Basic Problems and Solutions*, that art educators have a particulary important role to play in this attempt to equalize education. In the light of recent scientific findings, artists no longer need feel the slightest inhibition in resisting the myth that rationality is superior to sensitivity, or in pointing out that this myth leads to a half-brained educational product. More specifically, art educators can implement their creative, aesthetic inclinations by adopting in practice an approach conforming more directly to their ideals. Of art curriculum, at all school levels, the following question can be asked: How can our teaching method be best improved for immediate, affective encouragement of the right hemisphere?

As an individual interested in fine arts, and as a parent concerned about the cultural development of my own children, asserts Bogen, there are some other, more specific questions that seem pertinent. Is not the present training in the "scientific" basis of art (the theory of colour, the nature of materials, the mechanics of perspective, etc.) as well as the disciplines of drawing and painting, clearly directed toward only one, the left hemisphere? Does not the learning of a panoply of technical skills tend to postpone rather than accelerate the cultivation of the right hemisphere? Would it not be better to start with the simplest medium and the most primitive skills, not proceeding to other media and skills until the habits of aesthetic creativity are established? Should not these habits include, in particular, an intense awareness of the structural requirements for the overall unity of work?

The art educators need to realize that it is not the function of the school to consider only the specially gifted. The objective should be to develop in all children under his care the power to create and the power to express themselves in a graphic form. Such powers are precious possessions, and the ability to participate in whatever path in life is chosen is an asset of priceless value.... Herbert Read was never tired of saying, "We are all artists."

It is not only art which can cultivate the other side of the brain; many other subjects within the curriculum can help. The demand for the inclusion of art, literature, music, ethics, religion, drawing and the humanities in all curricula arises out of a growing conviction that since scientific knowledge has no claim to supreme validity and indispensability, those who are to be improved desperately need to learn in non-scientific ways about other truths. Douglas Sloan asserts the primacy of the intuitive imagination and points to a new epistemological radicalism beginning "to argue persuasively that the arts and religion and the humanities are not expressions of feeling or fancy or folk preference, but real sources of knowledge about the world in which we live." Abbs (1981) has stated some of the implications of his reflections on the place of the arts in education, and, more specially, the place of the image in education:

> In expanding our concept of knowing to include such knowing as can be inwardly acquired through mataphor we dramatically enlarge our view of the curriculum. In particular (although, of course, image is not confined to the arts) we draw the arts into the centre of the curriculum. The arts represent a fundamental way of knowing and assimilating experience and therefore must form an essential part of any core curriculum.
>
> Furthermore, our understanding of the arts in education changes. Our emphasis does not fall on "knowledge about" or "history of" but more on the active process of making in relationship to an inward unfolding. The arts are seen as the living symbolic process through which subjectivity is given form, meaning, and coherence. This is not to dismiss cultural heritage or technical "know-

> how" but to see these elements as serving a deeper process, the movement that in this paper, following Carl Jung, we have called individuation. This process lies at the very heart of the arts and is another way of defining one of the true and enduring ends of education.

Educating the whole child will be possible not when there is non-involvement of human faculties in natural processes which results in what Herbert calls the "atrophy of sensitivity" (Read, 1967)—anaesthesia, but when there is release of human potentialities and the consequent reduction of alienation and its concomitant pathology, social and personal. This emphasizes the role of visual education which can occur through many forms of communication in the schools which appeal to the creative, visual, and comprehensive capabilities of the right brain. Art, music, or poetry can correct the eye of the mind by exercising and so developing certain capacities of vision in it, which analysis leaves underdeveloped; and thereby they enable us to become aware of realities, on which the reason can reflect, and on the basis of which it can construct a philosophy; but if we ever miss or ignore these realities, we shall have a very inadequate idea of the world, and lack the necessary material for a philosophy of life (Livingstone, 1952). These subjects perhaps attempt to find in the universe, in matter as well as in the facts of life, what is fundamental, enduring and essential (Bellow, 1977). They help in a major restructuring of our experience. They provide peak experiences that are reported as the great joy, the ecstasy, the vision of another world or another level of living. The rhythmic experience—the good dancing of rumba, or the things that the kids can do with drums, the love for, awareness of, and reverence of the body—these clearly are the good paths to peak experiences (Maslow, 1971). They in turn are good paths (not guaranteed, but statistically likely) to the "cognition of being", to the perceiving of the platonic essences, the intrinsic values, the ultimate value of being, which in turn is a therapentic like help toward both the curing-of-sickness kind of therapy and also the growth toward full humanness. For Maslow (1962) music, rhythm, dancing are excellent ways of moving towards the discovering of identity. It is essential to listen to the whispering breeze, the reverberating sky, the silent pond, the howling storm, the mute hill, the gentle pasture. Exposure to, and responding to, the world of animal sounds—bleating and neighing, wailing and howling, grunting and hissing, blowing and rattling, mewing and purring, bellowing and trumpeting, growling and snarling, trilling and chirping, twittering and piping, crowing and cawing—all these help the development of the senses (Dixit, 1978). Such triggers tend to do all kinds of things to our autonomic nervous system, endocrine glands, feelings, and emotions. It just does. We do not know enough about physiology to understand why it does.

Such courses cannot be considered as a sort of whipped cream or luxury or soft education, but this type of education can be a glimpse into the infinite, into ultimate values. In *Tapovan*, a profound and major exposition of this subject, Tagore wrote on the great educational significance of the "education of the feeling", or *bodher sadhana*, as he put it. It is not merely an intellectual cosmic consciousness that is sought. A cosmic sentiment, comprising a profound, effective and imaginative apprehension of all existences in the universe, a close and intimate realization of the unity of all life and objects, is an aim of the highest importance.

Tagore gave a full exposition of his idea in a remarkable document, entitled *Movement in Education*, which contains consolidated notes of his talks to Elmhirst. Here he elaborated the theory that the thought processes receive impetus, momentum, and strength if accompanied by bodily movements.

> To compel the mind to use only one portion of the body in the learning process is not natural. In the process of talking in and digesting on food, a whole symphony of life is being performed in which heart, eyes, tongue, and ears are playing their part. The same processes should occur when you are taking your lessons or trying to swallow useful information. Life should be entire, a coordination of all the different faculties and functions. I am perfectly certain that if the whole body were active in all its functions, we should learn that much rapidly.

Elsewhere he proposes that children should retain "their natural gifts of bodily expressions, making use, for that purpose, of all their limbs". "In the developing of your school," he said to Elmhirst, "I advise you to make the picture of drama and of the histrionic arts compulsory for all children. We must make dramatic performance a regular subject of education. Children need the opportunity to give expression to their sentiments through perfect and graceful movements of the body. Never allow this capacity to use the whole body as a medium of expression to die out. Body movements provide a satisfying experience that is closer to an aesthetic experience. All kinds of body movements—perambulating or spasmodic, swaggering or convulsive, grovelling or milling around, twisting or sweeping, springing or truckling, spinning or gliding, wiggling or tripping, etc., are the stock of expressive resources of the body language, which a dancer uses in a most articulate aesthetic statement but he does so only after exploring their possibilities thoroughly." And what is true for a dancer cannot be otherwise for a child (Dixit, 1978). These experiences will enrich his life and develop aesthetic sensibility.

There is a perceptive account by Wagner (1978) on the relationship between drama and the right hemisphere. She makes a very strong case for the use of educational drama to stimulate right hemisphere activity. She pleads for inclusion of this subject in the list of those now shown to have right hemisphere input. The obvious relationship between the activity and the guided fantasy is seen in a description of educational drama with 5th graders taking an imaginary voyage in space. This whole article is very much worth reading by any drama or English teacher interested in right hemisphere stimulation. A significant observation is reproduced:

> So what does all this have to do with educational drama? Simply this. Dramatic inventing, the improvisational mode of drama, often referred to as creative dramatics, is as dependent on right-brained as on left-brained functioning. Drama can begin only when the participants agree to believe that a certain set of conditions is defining their action. Only by this act of will—the will to believe by all who take part—is drama possible. This deliberate decision to believe is perhaps one of the clearest ways to

> contrast right-brained from left-brained function. One's senses bring the left hemisphere a picture of the real world or of what passes in the left hemisphere's logic for "the real world". We often say, "seeing is believing". This is not the way the right hemisphere works. To become truly receptive, you have to believe before you can receive. In other words, believing is seeing. Awareness emerges as you consciously focus on the believed moment. To get themselves into a drama, many participants find bodily, especially rhythmic, movement helpful. Such activity focuses the attention in a state of relaxed concentration in much the same way as does the repetition of a mantra or the focus on a mandala or specially constructed visual image in yoga practice. By slowing sensory input and concentrating on believing that one can know in another mode, inner "seeing" becomes possible. The one demand that the art of drama relentlessly makes—even of the youngest of children—is to believe. "We are on a rocket to the moon"; "This is the middle of the hot and steamy jungle"; "On this hill we can catch our first scene of the sea"; "We have no one here to help us in this frozen waste but these dogs", and so on. This is not to say that in drama participants really are transported to a make-believe world. Except for very young children, most persons who engage in dramatic invention have the heady experience of having it both ways. They both believe the drama and at the same time are clearly aware that it is their own invention. It is a group fantasy they have created together . . . something real and shared and at the same time something imagined and gossamer.

Richard Livingstone (1952) also favours the use of drama in education provided that the plays chosen are really great (from the point of view of education; perhaps from any point of view to act second or third-rate plays is useless). Learnt by heart and acted, great drama is absorbed by the mind and becomes one of those unconscious influences which mould thought and feeling and personality. He reports that a man whose career has not lain in the fields of scholarship once told him that the greatest educational influence of his life was acting as a boy in the *Agamemnon* of Aeschylus at Bradfield.

Despite such crucial relevance of art, music, dance and drama for right hemisphere development, school curricula treat these as an incidental concern. Youngsters, as they go through the middle and senior high school years, are often denied opportunity to develop their expressive maturity and for intelligent response to the art of others. This impoverishes education. The arts, as Jordon (1974) maintains, are feebly represented in curriculum in schools. The type of experiences provided do not offer what Eisner (1978) calls the "educational encounters" or "vision of the possibilities", but they could be better classed as "anaesthetic rather than as aesthetic experiences". The role we have given to arts in education is one that contributes to sterility and alienation and leaves their full worth unknown. Clearly we need to reconceptualize this role. The arts should be at the core of the curriculum and the heart of the educational experience rather than "teetering precariously on the edge, longed for unconsciously by everyone, understood by few, and ignored or unsupported by most administrators". (Jordon, 1974). Even art educators have to change and reform their approach to teaching. More emphasis is to be placed on expression and "experience of the experiencer" (Mooney, 1975) than the correct use of art materials and the development by the students of acceptable art products. What is important is the originality, spontaneity, vitality and "uniqueness of students' personality and development" (Naumberg, 1971). This end cannot be brought about, however, until there occurs a radical reorientation with respect to teaching and evaluation in art and related subjects. Dixit (1978) provides an excellent account of how various media could profitably be used to develop the potentiality of children.

These subjects undoubtedly satisfy the human instinct which hitherto has been starved, but other subjects in the curriculum (among them, through natural science) can also help achieve expressive objectives if taught with insight and changed emphasis—with an invitation to explore, defer or focus on issues that are of peculiar interest or import to the enquirer. An expressive objective is evocative rather than prescriptive (Eisner, 1969).

In conclusion, Aldous Huxley premises that when education takes the subjective self into account, "... from being an activity mainly concerned with symbol, education will be transformed into an activity concerned mainly with experience and intuition ... an everyday mysticism underlying and giving significance to everyday rationality, everyday tasks and duties, everyday human relationships". Further, a man, he noted elsewhere, can be a Zen Buddhist electrical engineer.

ROLE OF PLAY

Besides art and music, one of the principal ways which brings reality to the inner vision, to the right brain's images, is play. Play has long been perceived as an activity that is characteristic of man and has often been associated with the realization of human potential. "Man only plays when in the full meaning of the word he is man, and he is only completely a man when he plays." (Schiller, 1902). Play, besides helping in learning, also contributes to the individual's capacity to open the boundaries of the psyche and to perceive and know with his whole being. The Plowden Report records: It is the way through which children reconcile their inner lives with external reality. In play children gradually develop concepts of causal relationships, the power to discriminate, to make judgements, to analyse and synthesize, to imagine and to formulate. Children become absorbed in play, and the satisfaction of bringing it to a satisfactory conclusion fixes the habit of concentration which can be transferred to other learning. Play gives an opportunity to use imagination, make-believe, fantasy and creativity. It uses the energy of the child's mind, spirit, and body and through it expresses a whole range of feelings and emotions with ease and without embarrassment or self-consciousness. The fun of playing, as John Huizinga (1955) admits at the outset of his book, resists all analysis, all logical interpretations. Children who develop through play find their way to the opportunities that are appropriate to them more through tentative efforts and trials in the open situation. They become more inventive, more creative, and more sensitive and remain young longer, as a reflex action to the continuing play situation, which assists personal flexibility

(Rohrs, 1982). The constructive role of play in the development of the personality has always been part of Erikson's development theory. Erikson writes (1972):

> Piaget, of course, spoke of cognitive gains. But let me suggest in passing that such play procedures as the one described may well facilitate in a child an impulse to recapitulate, and, as it were, to re-invent his own experiences in order to learn where it might lead. If there is something to this, then we may entertain the dim hope that some such play procedure may become an adjunct to early education rather than remain a method in the service of clinic or of research only. But what seems to be the *function of playfulness* in the children's responses both to Piaget's cognitive challenge and to our expressive one? The most general answer necessarily points to a quality of all things alive, namely the restoration and creation of a *leeway of mastery* in a set of developments or circumstances.

A review of the most salient modern developmental theories of play, namely Piaget's cognitive theory, psychoanalysis, and symbolic interactionism, reveals indications of the value of the earliest phase of play in the development of a special mode of creativity in perceiving, in knowing, and in experiencing oneself and the world; all these point in the same direction—toward a body consciousness that is an integral part of the open system of the evolving self (d'tteurle, 1979). All these advantages of play make it profoundly important that it is used along with other techniques which, according to Tagore, may provide nourishment to the body, happiness of mind, and the satisfaction of the natural impulses of childhood. These techniques will go a long way towards cultivating the other side of the brain.

Teaching for Discovery of Personal Meaning and Developing Experiencing System

Teaching, as Ross Mooney (1965) observes, involves helping the learner become aware of the presence and uniqueness within him of his experiencing system, how it works, how he can consciously affect it, how it comes together in its own particular ways, his particular style of mind, his individual mode of grasping, his unique tempo and rhythm, etc. Teaching, therefore, aims at helping the learner discover his individual value and pathway through to his own most complete fulfilment as a creative creature. Teaching should provide numerous experiences and opportunities to experience growth as described by Maslow (1962); otherwise sickness results—the sickness of not growing. Kelley (1962) calls it "perceptual malnutrition" which results in the potential getting stymied so that it can no longer progress. Whether or not learning is effective is largely dependent upon the individual's discovery of the personal meaning of ideas. When teaching does not provide scope for discovery of personal meaning the self of the individual grows towards inadequacy, rather than towards adequacy. Instead of creating within the child his own "interior culture and reach discontinuous realms of experience" (Bruner), many traditional educational procedures emphasize on repetitive drill and repetitive grill, the automatic, uncontrollable, and obligatory repetition which are at the heart of the neurotic process (Bower and Hollister, 1967). What is found mostly is unidirectional flow, a truncated communication of "instruction" punctuated by fixed alternative response. This obviously results in creative sterility.

Highly rational indoctrinating and restrictive demands which make education dull and passive, permeate a great many classrooms. We teach only one part of the living, functioning, interacting child, his brain. He has more than just a brain, though. He has feelings, senses, and a body as well (Castillo, 1976). The right brain is perhaps characterized by preconscious, but as Kubie (1975) maintains: psychologists, psychiatrists, neurologists, neurophysiologists have erred together in their undue emphasis on the conscious components of mentation. This has led the educator into neglecting the preconscious instrument of learning, which is the effective instrument of recording, processing, and creating (Kubie, 1967). It is this psychological domain that gives rise to creative thought and has relevance for understanding the genesis of speculation, phantasy, and productivity. The preconscious for Kubie resides in the right area and performs just the proper functions to foster most efficiently the phantasy and imagery necessary for creative ideation. Kubie speaks: In the adult who is not hamstrung by conscious or unconscious fear and guilt, preconscious processes make full use of analogy and allegory, super-imposing dissimilar ingredients into new perceptual and conceptual patterns, thus reshuffling experience to achieve that fantastic degree of condensation without which creativity in any field would be impossible (Kubie, 1967). The pedantic teaching of the three R's tends to lock the jail door which imprisons the child's capacity to learn and create. Most of us have been brought up in the belief that 'thinking' is synonymous with verbal thinking, and philosophers from Athens to Oxford have kept reasserting this belief unfortunately. Koestler (1971), criticizing this, asserts:

> . . . Whole evidence points in the opposite direction, summed up in a single sentence in Woodworth's classic textbook of experimental psychology: "Often we have to get away from speech in order to think clearly". And we have heard one testimony after another from great scientists, which show that in order to create they had to regress at times from the word to the picture-strip, from verbal symbolism to visual symbolism—some, like Einstein, even to the Kinesthetic sensation of muscle-motions. The word regression is appropriate, because the high *aesthetic* value which we put on visual imagery should not obscure the fact that *as vehicles* of thought, pictorial and other non-verbal representations are indeed earlier,

> both phylogenetically and ontogenetically older forms of ideation, than verbal thinking. Kekule's "Let us dream gentlemen" is an invitation to regression which prepares the forward lead, a *reculer pour mieux santer*.

A large amount of telling and showing which characterize the pedagogical approach regulates and directs the process of meaning generation and freeing of the preconscious. Again and again Bruner emphasizes that instruction as far as possible should have the objective of leading the child to discover for himself. In an almost poetic style, Bruner (1965) suggests an important base for developing a theory of teaching for the right brain. He has called for more "left-handedness", dreaming, intuiting and less "right-handedness" or formal analysis. That may encourage intuition or "intuitive leaps" which involves insight, the apprehension of meaning suddenly and dramatically, the "ah ah" phenomenon by teaching structure—by raising the questions scholars are discussing, at the same time providing a stimulating, open, intellectual climate. In a fascinating way Bruner sees intuition as an end and as a means, a cause and an effect, of teaching structure. A teacher encourages pupils to be intuitive so that they may arrive at an understanding of the structural ideas, and, in turn, the acquiring of these ideas develops intuitive powers. One begins to teach on the basis of the child's natural but underdeveloped powers of insight and then develops them. The appealing idea of intuition is, of course, itself intuitive. There is a great delight of having students engaged together in first intuitive and then analytical thinking.

In another book, *On Knowing*, Bruner has further developed this idea. He uses the subtitle 'Essays' for the left hand, by which he means an approach of knowing "whose medium of exchange seems to be the metaphor paid out by the left hand". In explanation he continues:

> It is a way that grows happy hunches and 'lucky' guesses, that is stirred with connective activity by the poet and the necromancer looking sidewise rather than directly. Their hunches and intuitions generate a grammar of

> their own searching out connection suggesting similarities, weaving ideas loosely in a tria web.

Here Bruner suggests another way of knowing or meaning generation, whose implications for education and right brain development have only begun to be explored. If we can find room in education for both the intuitive and the analytical approaches, we will have a useful arrangement. Not only will it help individuals to stay in connection with other individuals engaged in vastly different pursuits but it will help them stay in touch with each other.

A theory of teaching which helps in developing the cerebral symmetry will perhaps strike a balance between the *expository* mode and the *hypothetical* mode of teaching. The expository mode obviously suggests that the pace, style, and mode of exposition are principally determined by the teacher as expositor, and the student as the listener. The former has a wide choice of alternatives for structuring: he is anticipating paragraph content while the listener is still intent on the words, he is manipulating the content of the material by various transformations, while the listener is quite unaware of these internal manipulations. In the other mode, the teacher and the student are in a more cooperative position. "The student is not a bench-bound listener, but is taking a part in the formulation and at times may play the principal role in it. He will be aware of alternatives and may even have 'as if' attitude toward these and, as he receives information he may evaluate it as it comes."

It is suggested that another important element which may characterize teaching style, should mostly let the student develop a subtle enough way of doing things so that the student retains the sceptical, the tentative, the wondering art of constructing conceptual schemes. The strategies should also give credit to the expression of highly subjective intuitive ideas. Teachers have to recognize the legitimacy of intuition, creativity, and divergent thinking as an intellectual operation. The students need assurance, as Bruner asserts, that it is all right to entertain and express highly subjective ideas, to treat a task as a problem where you invent an answer rather than find out there in the book or on the blackboard. Some subjective and imaginative and impulsive thoughts may not produce the "right answer", but they extend the conceptual possibilities for the child, when expressed. This suggests that the child should be encouraged to reach out and find regularities and relationships in his environment. He must devise his own ways of searching and finding. To make this possible it is necessary to create conditions in the classroom that permit and support autonomous search, information processing, and theory building. The teacher in such a system has to provide for both, the didactic teaching in verbal learning as well as heuristic or nonverbal learning. He has to understand the study of his subject as a "dialectic of inquiry" rather than as the communication of "rhetoric of conclusion" to borrow two of Joe Schwab's felicitous phrases. Thomas Acquinas maintained that the teacher "digs ditches", that is, makes problems which he and the student must fill or solve, if emptiness and dissatisfaction are not to result. And the recurrent principle quoted throughout his work, that "knowledge is received according to the manner of the receiver", points to no passivity but rather the determining form of action in the student, where all knowledge begins and proceeds. The teacher has to show greater respect for the ideas of individual children and for derived meaning, than for delivered meaning. There must be a heightened sensitivity to individual differences in conceptual structures, cognitive style, motivational patterns, and amount and type of stored data.

Information about the processes that characterize cognitive styles can be useful in matching instruction to individual differences. For example, Pask and Scott (1972) classified learners as serialists or holists and wrote serially ordered and holistically ordered instructional material to teach a zoological taxonomy. The serialists and the holists learned much better when the instructional materials matched their cognitive styles than when the materials did not match their cognitive styles. The study exemplifies one way instruction can be improved when it is based upon process-oriented cognitive styles that relate to knowledge about the encoding strategies of the brain. The more the teacher knows about the students' thinking and learning styles the more effectively he can create optimal conditions to stimulate and sustain the autonomous search for meaning. The conditions include freedom for the children to search, gathering data and testing ideas. Interesting research evidence is quoted by Wittrock (1978).

Zelniker and Jeffrey cogently related cognitive style to a model of cognitive processes of the brain. They (1976) hypothesized that reflective children (that is, children who are above the mean on accuracy and above the mean for latency of response) differ from impulsive children (that is, children who are below the mean on accuracy and below the mean on latency of response) in their information-processing strategies. They found that the reflective children used a left hemispheric, analytic-cognitive style and the impulsive children used a right hemispheric, global-cognitive style. On problems involving matching figures by their details, because of their analytic style the reflective children were more accurate than the impulsive children, while on comparable global problems no difference between the groups was found. The difference in information-processing strategies, analytic versus global, or part scanners versus whole scanners, nonverbal process versus imagery, explained the difference in accuracy between the reflectives and the impulsives. One important educational implication of Zelniker and Jeffrey's findings is that impulsive children, who are relatively more frequently found in the lower socio-economic classes, are not always inferior to reflective children in problem-solving ability when a global strategy is appropriate to the solution of the problem. For teaching, the finding implies that we can expect learning to be difficult when a mismatch exists between a child's global-cognitive strategy and the analytic organization of many curricula and instructional tasks.

Another promising strategy to cultivate the right brain is to stimulate greater sensitivity through the technique of actively guiding the child to a more differentiated perception and through increasing the proportion of direct contact he has with the phenomena about which he is learning. The world outside the school walls, the larger environment, is, therefore, important material for study. As a part of this, Bruner recommends, there is often a need to devise emotionally vivid special games, story-making episodes, or construction projects to establish in the child's mind his right not only to have his own private ideas but to express them in the public setting of a classroom. This will also help getting out of the children instead of putting into them which, according to Siegel (1961), is an index of effective teaching. Great stress should be put upon the individual work by the students. This "individual work", as Joshi (1974) maintains, may be pursued in several different ways:

by a quiet reflection or meditation;
by referring to books or relevant portions of books suggested by the teacher;
by working on "work sheets" prepared for the students by the teacher;
by consultation or interviews with the teacher;
by carrying out experiments;
by solving problems;
by writing compositions;
by drawing, designing, painting, etc.;
by any other work, such as decorating, cooking, carpentry, stitching, embroidery, etc.

Expression by the students is so important that Tagore is reported to have maintained: The most important thing is that there should be daily practice by pupils in expressing immediately what they are learning. Again, if we express a thing as soon as we learn it, our conception of it could become sound. It was a pleasant surprise for him when he found this idea of his actually in practice in the schools in Soviet Russia. "One great merit in the Russian educational system is that the children draw whatever they learn from books. This helps in forming in their minds vivid images of things they learn, in developing their skills in drawing, as also in blending with studies the joy of creation."

Teaching techniques should deliberately teach pupils to synthesize as well as to analyse. It is a process which can be set going in every subject. The academic method, writes Karl Mannheim, which produces lack of awareness is over-specialization. . . . The student is never encouraged to think of situations as a whole. . . . But the craving for some coherent vision cannot be completely suppressed, and without adequate training in the methods of synthesis, students are bound to become an easy prey either to dilettanti or to propagandists who exploit their craving for their own or for their party's benefit.

A remarkably effective way of stimulating right-hemisphere thinking is, perhaps, the use of metaphors (analogies and similes). They provide awareness of the relationship between dissimilar objects and situations. Poets have probably understood the power of metaphor. Metaphors help us to shake off our blinkers and to perceive the familiar with a sense of awe and the awful with a sense of familiarity. Metaphorical ways of knowing may help the student to learn the skill and pathways of getting from one metaphor to another as knowing all there is about a single metaphor. The richness and varieties of knowing are often found in transmetaphorical experiences. To learn how to shift skilfully, comfortably, and appropriately in our thinking from one metaphorical matrix to another and back is a consummation devoutly to be wished for in all educational processes (Bower, 1967). Children should also be permitted to make use of imagery. Jerome Singer (1973) reminds us that images are coming back into their own, as the relationship of imagery to a child's learning is being examined. Singer believes that the child who is equipped to use images is prepared to learn, and that the imaginatively active child can carry that make-believe into creative adulthood. He suggests that parents should provide fantasy material for their children and play games of pretending with them. Guided fantasy experiences with juvenile literature can be effective in helping children practise the production of images, particularly when an adult interacts with them as they interpret and react to the storyline (Noyce, 1979). Related to this is the teacher's emphasis on permitting students to channel constructively some of the time and energy to day-dreaming. Recent research has confirmed that fantasy has the power to involve and excite. The ability to day-dream, to "make the strange familiar and the familiar strange", has been linked to creativity in fields from engineering to social work (Gordon, 1974). A quote from Einstein saliently affirms this premise: When I examine myself and my modes of thought, I come to the conclusion that the gift of fantasy has meant more to me than my talent for absorbing positive knowledge" (Clark, 1971).

There are other ways also to provide for individual differences in hemispheric functioning pattern and ultimately in learning styles. One educator (Wittrock, 1976) suggests that complementary functioning can be best facilitated by determining the child's preferred modality and then designing instructional strategies and materials which will directly challenge the preferred hemisphere first and then provide secondary instructional experiences which will encourage the other hemisphere to participate in the activity.

Wittrock (1978) observes: One paradigm for educational research that emerges from these studies in neurology, psychology, and education emphasizes the importance of the mental processes and intellectual backgrounds of learners in determining the learning that occurs during instruction and teaching. Within this paradigm, research in teaching and learning focuses upon understanding the individual student's previous learning and cognitive strategies and upon instruction and teaching that builds upon that learning and those strategies. In this paradigm, the same treatment may mean different things to different learners, and different treatments may be needed to attain the same ends with different learners.

In other words, for the left-brained thinker new concepts would be introduced in an analytical manner with verbal emphasis, followed by nonverbal "hands on" exploration of materials to encourage spatial-synthetical modality. We may be able to help the child by what the child initiates. Eventually, we may have adequate guidelines to facilitate a child's voluntary self-development and self-control of biological mechanisms that enhance learning potency. Another educator (Hunter, 1976) pragmatically concludes that prior knowledge of the child's dominant modality is necessary. This encourages the educators of young children to vary instructional techniques till the correct match for a given child is found. However, if neural organization can be predicted by factors such as sex and hand-eye dominance as well as early reinforcement patterns (parental and cultural), prior determination of the dominant modality should be predictable (Kraft and Languis, 1977).

In any case, the teacher has to know the cognitive level and neural organization of a given child. It may give educators a powerful tool for facilitating learning by constructing an appropriate learning environment and planning effective strategies which match the children's level of neural development. "Differences in cognitive style may prevent a child from learning when faced with teaching and organized content that is not consonant with his ways of knowing." Suchman's (1964) early research did reveal this to be the case:

> . . . children with high analytical styles of thinking tended to inquire more analytically, gathering data primarily for the purpose of analysis. The relational (low analytical) children were more inclined to form hypotheses based on impressions, bypassing the analytical process. The children selected inquiry strategies that best suited their styles of thinking.

Therefore, a knowledge of the children's mode of processing and awareness about various modes of processing to suit the child's neural development is essential.

It would be rewarding to quote Wittrock (1978): The individual differences suggested by the research reviewed here emphasize information-processing strategies. Instead of age, sex, and intelligence, the strategies of learners, such as analytic and holistic strategies, promise to lead more directly to theoretically interesting instructional procedures. By the same reasoning, studies of student attributions, encoding processes, and attentional and motivational mechanisms may also lead to improved instructional procedures. Instructions to elaborate concepts and issues, in different modes or different strategies, questions about the meaning of subject matter, metaphors, similes, and analogies to induce comparisons, and hypostatizations to represent abstract concepts are all potentially important ways by which teachers might facilitate the constructive-cognitive processes of the brain.

In sum, the teacher, more than the subject matter, is given new importance and original challenging functions to perform with students. The basic implication (for teaching) is that teachers need to understand and to facilitate the constructive processes of the learner.

The learner is also given a new, more important, active role and responsibility in learning from instruction and teaching. To learn, one should attend to the information and concepts, and construct, elaborate, and extend cognitive representations of them. The teacher can facilitate these processes, but the learner is the only one who can perform them.

Brandwein (1975) has developed a theory of teaching from the point of view of the duality of the mind and human consciousness. His theory of teaching considers education to be greater than schooling.

> It recognizes instruction as a joint process involving teacher and students in a common effort designed to produce change or to enrich their lives. It recognizes the value of selection and ordering in what is to be learned. It calls for evaluation to demonstrate the effectiveness of the learning process, and it chooses types of experiences that are of greatest value in achieving stated goals.

Some strategies for the greater use of the total mind, applicable at all grade levels, have been suggested in response to such issues as attending to alternative form of consciousness, using the holistic method to process information, and determining the relationship of the identity of the parts to totality or wholeness. These would be applied within the "constraints of classroom" and the "daily schedule" a teacher is called upon to maintain. These are:

1. Children should absorb some experience through non-segmented and non-sequential modes.
2. We should seek to loosen or free the paradigm.
3. Reductionist explanations should be loosened or avoided.
4. Intuition should be considered as a complementary function of intelligence.
5. Children should be encouraged to rely on subtle or primitive expression.
6. We should seek to broaden category widths.
7. Teachers need to utilize more forms of listening.
8. Children must be afforded more waiting time for responses.

9. Decisions must not be based only on observable phenomena.

In the end, Brandwein admonishes:

> Your attention to this new explanation of human consciousness should lead to greater psychological safety and freedom. It should also remind us of a higher ethic: that *there is nothing so unequal as the equal treatment of unequals*. We must in our classroom treasure the poet, the painter, the dreamer, as well as the scientist, the mathematician, the logician. In doing so each child then becomes an individual of supreme moral worth.

This makes it essential that teachers realize and appreciate great breadth and complexity of mind-power potentials. A vast untapped harvest in mind-power can be developed by teaching directly and separately and in the process each world of work talent will function in the classrooms. Some of man's greatest inner powers and resources are his multiple high-level talents. A major challenge is how we can teach pupils in classrooms to use more of their brain cells and pathways, i.e., more of their many brain talent processes and thus more of their potential talent powers. It is possible in the student-centred approach where teachers focus upon talents and become talent developers. The teacher learns to structure the classroom setting in a certain way and to a certain degree in order to elicit a given type of talent in students. Next, the teacher uses quite a different structure for a second talent, and so on. The teacher is very active in setting structures, in observing students, and in entering in at the times and in the ways that facilitate the functioning of the specified talent processes in students. Use can be made of the multiple talent approach (Taylor, 1973) which has emerged from sustained research on talents. A breakthrough in teaching for creativity breaks away from the narrow band of academic-and-intelligence talent and expands into teaching for several other high level talents heretofore largely ignored and left dormant in typical classrooms. The main goal in Multiple Talent Teaching is to have students use many more of these neglected talents than they do at present. Through this approach, as Calvin Taylor asserts, nearly all students can be above average in at least one of these many intellectual talents, which can now be functioning in classrooms. Furthermore, students can use each of these multiple talents to process information across all subject matter areas and thereby acquire greater knowledge and also work at the fringe of knowledge and beyond. "Instead of conceiving of students as merely learners and reproducers, we esteem them much higher as thinkers and producers, decision-makers, communicators, forecasters, creators, etc. Rather than depriving them of these 'adult prerogatives', teachers have them deal with knowledge in all these talented ways. The youngest are remarkably ready to function in these adult-like activities. They even become more full-fledged children in the process, being livelier, healthier, happier, and more self-esteemed and self-managed when their natural talent processes are growing and functioning naturally." Enough progress has been made so that it is now feasible to start implementing the Multiple Talent Teaching approach widely and economically anywhere in the world, first with those teachers who are most ready. This student-centred, talent-focused approach holds the best hope of systematically reaching each and every student in our classroom and of finding promise in all students (Taylor, 1973).

Various strategies can be, with modifications here and there, used in teaching various subject areas. Suggestions in the area of science education (Languis and Kraft, 1977; 1978) are available and so also for the teaching of mathematics (Wheatley, 1977), art (Friend, 1966; Rush, 1979; Pizzat, 1979; Vannatha, 1979), social sciences (Samples, 1976; 1977; Raina, 1981) and language arts (Torrance, 1973).

It will be realized that the right hemisphere is characterized by numerous functions and no one theory of teaching will suffice to develop these functions. After several years of testing and evaluating, Samples (1977) came to the realization that when one invites both mind functions into equal partnership, three things characterize the learning ecology: (1) higher feelings of self-confidence, self-esteem, and compassion; (2) wider exploration of traditional content subjects and skills; (3) higher levels of creative invention in content and skills. These have to be built into the model of teaching which aims at developing brain potential. A combination of models, which share many features, both with respect to the kinds of means they recommend is perhaps a useful approach to work out a system of teaching in this context. Inquiry model, which assumes that inquiry is "the pursuit of meaning" or a means "to obtain a new level of relatedness between and among separate aspects of one's consciousness (Suchman, 1966) or Inductive Teaching model (Taba, 1966) or Non-Directive Teaching model (Rogers, 1951) or, most importantly, the Synectics model (Gordon, 1961) or Schutz's (1958) Awareness Training model or Torrance model (1975) will have to be considered seriously to arrive at a meaningful model for the teaching of the right brain. Joyce and Weil's (1972) insight, of course, can provide wider horizons and possibilities.

These new ideas are as old as Aristotle's model of memory, Simonides' system for recalling information, and Quintilian's suggestions to teachers and students about the facilitation of learning. But these old ideas encourage a new unit of interest among people who study learning, instruction, individual differences, attention, memory, and the human brain (Wittrock 1978). In any case teaching, as Mooney (1963) believes, has to recognize the learner as an energy-system. It involves judgement of what most fits the balance and flow of energy in the learner's system, observing his intake and output, stimulation and response, listening and talking, observing and participating, thinking and acting, playing and working, etc., seeking maximum balance and flow of vitality as a means to maximum usable learning.

Institutional Climate as Dialectical Unity

The brain is an exquisitely built tissue capable of being modified, for good or bad, by its environment (Teyler, 1978). It is built anatomically by genetic instructions, but development to human personhood is dependent on learning and environment (Eccles, 1981). Evidence from experiments including those conducted with Berkeley rats indicates the crucial importance of environment for the development of the brain. These Berkeley rats were placed in an "intellectually enriched" environment, and were assigned to graduate students who were admonished to give these rats loving care and kindness, teach them to run mazes, and in general to provide them with the best and most expensive supervised higher education available to any young rat of the University of California. After about 80 days of treatment when the brains of all the rats were dissected and various chemical and histological analyses performed, the results convincingly indicated that the brain of a rat from the enriched environment and presumably, therefore, with many stored memories, had a heavier and thicker cortex, better blood supply, larger brain cells, more glia cells, and increased activity of two brain enzymes, acetylcholinesterase and cholinesterase, than did the brain from an animal whose life has been less memorable (Krech, 1969). Such is the importance of environment in the development of the brain and hemisphere functions.

Environmental or socio-cultural differences have been usefully considered in the light of recent neurologic findings, particularly the asymmetry of cerebral hemisphere function mainly by Bogen* and associates. Such findings have recently become of interest to scientists from a variety of disciplines

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Joseph E. Bogen (Chairman), Symposium on "Aspects of Neurosociology" at the Fifth Annual Meeting of the International Neuropsychology Society, Santa Fe, N.M., February 1977.

(e.g., Borowy and Goebel, 1976; Paredes and Hepburn, 1976; Armstrong *et al.*, 1976; TenHouten *et al.*, 1977; Rogers *et al.*, 1978) who studied the effects of cultural stimulation on the brain.

The concept of hemisphericity which resulted out of Bogen's (1972) A-P hypothesis, suggests a tendency for a person to rely more on one hemisphere than the other. If such hemisphericity exists, it has been suggested, it may well reflect the influence of early cultural exposure. In a culture where most individuals are exposed to intensive education of the left hemisphere expect a tendency for the propositional mode to dominate, even when dealing with problems for which it is less appropriate. Conversely, persons raised in a non-literate culture emphasizing different training, in spatial skills for example, should exhibit a reverse tendency (Bogen, DeZure, TenHouten, and Marsh, 1972). Further, for a particular population, although the individuals will vary widely, we expect some central tendency in the relative reliance placed upon one or the other mode, a central tendency differing from that of another population. Any culture might then be characterized in terms of its ratio of appositionality to propositionality, that is, an A/P ratio (Bogen, 1971).

It has been suggested (Kinsbourne, 1975) that the development of hemispheric functions involves increases in proficiency and in learning to allocate attention to the hemispheric processes, rather than increases in degree of lateralization. In Kinsbourne's model (1973) lateralization is an attentional phenomenon. Each hemisphere activates its respective brain stem attentional mechanism to favour anticipation of verbal stimulus, and the left hemisphere voluntarily shifts attention to the right ear, or right visual field, or both. These strategies of shifting attention can be learned, differently with different stimuli, different ages, and different groups, not because of any difference in lateralization of function.

The Kinsbourne model leads to predictions about how instructions, sets, and intentions prime or induce right or left hemisphere processing, and how different strategies learned in different social classes by boys and girls might explain observed differences in the laterality of function. In the new field of neurosociology, TenHouten (1976) hypothesized that proficiency in verbal analytic processes correlates highly and positively with socio-economic status in industrialized societies. Some have also differentiated privileged and deprived groups in society in terms of hemispheric style.

This evidence clearly indicates that cultures and their educational systems influence the way people use their minds. For example, Tsunoda (1978a, b), a neurosurgeon with the Department of Auditory Disorders, Medical Research Institute, Tokyo Medical Dental University, has shown that the left cerebral hemisphere of the Japanese process a wide range of sounds, including non-linguistic sounds such as the utterances which reflect human emotions, and also animal cries, Japanese musical instruments, and sounds in nature. The range of sounds Westerners process in the left hemisphere is conspicuously narrower, apparently limited to syllables made up of both consonants and verbal sounds. The calculation, however, is handled in the left hemisphere by both the Japanese and the Westerners. Second and third generations of Japanese descent, born and reared in an environment where Western languages are spoken, such as in the United States and Brazil, develop exactly the same patterns as Westerners.

Cohen hypothesized that two incompatible cognitive styles, called analytic and relational styles, develop in cultures emphasizing either shared functions or formal primary social groups, respectively. Children with a relational or non analytic style should experience difficulty in schools and on tests where an analytic strategy is needed to succeed. She found that many standardized tests of intelligence and achievement, including nonverbal tests, assess a student's analytic-cognitive style and field-independent-cognitive style. She concludes that relational children in an analytically organized school environment face a cultural conflict, which is not the same as a cultural deprivation. Such tendencies which suggest the involvement of cultural emphasis have been tested by Torrance and Sato (1979) with Japanese and American students and by Raina (1980) with Indian and American students.

The purpose of presenting these neurosociological evidences has been to indicate the importance of physical, educational, and environmental variables in the use of minds. To help use both the hemispheres, the classical tension and conflict between

Realism or Absolutism on the one hand, and Nominalism or Relativism on the other, is to be practically wholly removed. Since the dominant values of our culture emphasize the belief in "the objective consciousness" (Roszak, 1969), educational institutions, aiming at developing it, look for sources of inspiration in the techniques of management and engineering. The technical, detached stance serves the same ideology that makes rigour important in dealing objectives. The demands created by this ideology tend to stifle intellectual curiosity and direct children to become passive and acquiescent to the network of rules, regulations and routines of the institutional arrangement of schools (Popkewitz, 1973). Even the sizes of the classes have been developed and standardized upon the basis of a "telling theory of education" and they in no way become places where the exciting experience of exploring and discovering meaning becomes central activity. The institutional environment hardly exemplifies the excitement and intrinsic values of learning through the creating and testing of meanings. The system, by and large, disregards the tacit dimensions of knowing, denies nonlinear relationships in the growth of knowledge, and ignores the normative qualities and values of cognition. Apologists for such a system prefer corporate metaphors, referring to teaching as learning management. Corporate aims are outlined so that exclusively systematic approaches favour monolithic educational systems with uniform materials and hardware, with uniformly trained teacher/managers marketing uniformly trained graduates. . . . In time, the innovative allure of the systematic turns out to depend on arresting promotions and alternative packaging. What the packages hold, however, is nothing but a formula for rote recall and a bromide for education—the simple transfer for information (Szilak, 1976). These values obviously suit the scientific and technical requirements of an industrial linear society, but these values have produced in school an environment that has been non-educative in the milieu and work it provides for children.

Since educational institutions are predominantly characterized by fairly structured and rigid forms of organization, they have almost become bureaucracies. The bureaucratic "machine-model" is efficient in managing routine and predictable activities, but its basic rigid design fails in responding flexibly to rapid changes in the environment (Nakata, 1972). It does not respond to natural curiosity, creativity, exploration or feeling to scan. It transmits dead metaphors or established concepts and does not encode new ones. Thinking is considered to fit Skinner's description of culturally conditioned thinking. This is one of the background factors underlying the pitiful results of the educational system. An illusion is created by the educational system that it achieves a high percentage of successes merely by using the simple device of dropping out its failures. Any method of teaching can produce spurious scores by quietly discarding those who cannot learn by that particular method, and turning its back on the question of how many of the discards might have learned by some other method (Kubie, 1967). The educational climate hardly matches the cognitive-emotional style of the children.

School is a praxis that should provide an environment that must deal with the realities of man's rational side as well as his emotional, irrational, intuitive sides. Nakata (1972) suggests some organizational values taking Warren Benni's list of metagoals or values of laboratory training, and Tannenbaum and Devi's (1962) scheme, as bases. These are:

To take a holistic view of man. This would mean emphasis on rational as well as irrational and intuitive capacities and not fragmenting artificially and irrelevantly.
To move from the distrust of people to trusting them.
To move away from the avoidance and negative evaluation of individuals towards their confirmation as human beings.
To move from resisting and even fearing individual differences towards accepting and creatively drawing out and utilizing them.
To have a spirit of enquiry.
To expand consciousness and choice.

From the above it logically follows that schools should provide for a variety and an abundance of encounters, possibilities, and alternatives. Refinement of sensory responses grows from the wealth of sense experiences offered, for example "the vivid colour on the walls or in the illustrations in the books, the low bong of the drums or the whisper of the triangles, the feel of wet in the clay, the softness of the rabbit's fur, and the straightness of the ridges on the turtle's shell (Biber, 1967). Capacities of the left and the right side of the brain suggest that the unity of schooling should be dialectical unity, a co-existence of contrasts. The function of school should be to provide experiences for exploring the immense diversity that man lives in, the innumerable aspects of things, and their variation from one moment to another. An environment is to be created, an ambience provided, that will facilitate the child's discovering and activizing the psychic being within (Srinivas Iyengar, 1974). Schooling should be concerned with the engaging of the individual in a personal dialogue with things in his world. To deny such experiences is to deny what is essential to man's identity. An atmosphere vibrant at once with ideation and silence, an atmosphere surcharged with a synthetic thought and a most integral aspiration, and an atmosphere filled with the widest realization and a harmonious unit—such an atmosphere is an indispensable condition of the perfect mental education (Joshi, 1974).

School environment as Cremin (1976) maintains should help in the emergence of a characteristic lifestyle, the core of which might be described using Gordon Allport's concept of the "proprium". It should take into account the child's particular way of meaning generation and, as a result, develop what Hope Jensen Leichter has referred to as an educative style, a set of characteristic ways through which an individual engages in, moves through, and combines educational experiences over a lifetime. All this, of course, is possible under certain conditions and most of all demands freedom—what Erik Erikson calls a "psychosocial moratorium"—for personal explanations and growth for a "search for something and somebody to be true to". The classroom has to become a place where the exciting experience of exploring and discovering meaning is the central activity. This obviously will give the student a chance of holding and presenting his meanings without ridicule or attack, and the privilege of seeing things the way he does, according to his own intellectual-cognitive style. The total school atmosphere need to be seen as one in which fun and play are truly welcomed and in which the student can feel comfortable while imagination, intuition, and visualization are given a free rein. This suggests the 'horizontal' rather than the 'vertical' organization for the schools (Combs, 1962).

In this context it may be of interest to discuss the two contrasting kinds of educational environments suggested by Robert Glaser (1973). One type is the selective educational mode and the other is an adaptive educational mode. A selective educational mode is characterized by minimal variation in the conditions under which individuals are expected to learn. There are limited instructional possibilities available. Talents do not flourish, and alternatives are not encouraged. "In such an environment, the fixed or limited paths available require particular student abilities, and these particular abilities are emphasized and fostered to the exclusion of other abilities." This type is perhaps antithetical to the development of the right brain.

The adaptive mode is flexible, where a wide variety of talents are encouraged. Various means of learning are available and various opportunities for success are possible. An individual's style of learning and thinking, his modes of meaning generation, his talents, and his background are recognized. "A selective mode operates in a Darwinian framework, requiring that organisms adapt to, and survive in, the world as it is an alternative in that the environment can be changed. . . . In any educational mode, then, the individual differences that take on outstanding importance have ecological validity within a particular system."

It is the adaptive mode that will make possible independent, imaginative exploration and bring the child into lively contact with a vital flow of experience stimulating sensitive, discriminating perception. In any case, the present management models need to be replaced by humanistic models which stress the qualities of the other half of the human brain.

Educational Equilibrium and Neural Symmetry

> Poetry of many kinds . . . gave me great pleasure, and even as a school boy I took intense delight in Shakespeare, especially in the historical plays. I have also said that formerly pictures gave me considerable, and music very great, delight. But now for many years I cannot endure to read a line of poetry: I have tried lately to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also lost almost any taste for picture or music. . . . My mind seems to have become a kind of machine for grinding general laws out of large collections of facts but why this should have caused the atrophy of that part of the brain alone, on which the higher tastes depend, I cannot conceive. . . . The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature.
>
> From *Autobiography of Charles Darwin*

The current disease of disequilibrium, which has caused what Samples (1978) calls rational neurosis, emphasizes overindulging linear, eculidean paradigm within our society and cultural ecology. This disequilibrium very conveniently results in the atrophying and stultifying of vital human functions. One can cite numerous examples to indicate how educational, political, and legal institutions have created an ecology of culture that is almost entirely cast in the prevailing vision of linear modes of thinking and knowing. Education is dedicated to sequential experience, politics to the logic of rules and elections, and law is devoted to precedent and order. That these are worthy and virtuous is not the issue. But that in fact they are *just* is the issue (Samples, 1978). There is disequilibrium and imbalance in educational values, priorities, and consequent emphasis. In the "poker chip milieu" of the educational system, the only reason for teaching, reading, and learning is that it brings extrinsic rewards, makes a person other-directed and paralyses his imagination and fantasy. About such people Maslow (1966) observes with interest:

> They seem to be empty, out of touch with their own inner signals. They eat, defecate, and go to sleep by the clock's cues, rather than by the cues of their own bodies. They use external criteria for everything from choosing their food ("it's good for you") and clothing ("it is in style") to questions of values and ethics ("my daddy told me to do").

This extrinsic education passed in the form of systematic education promotes functional fixations, insulates the mind against discoveries, and ultimately drives out creative and metaphorical thinking (Szilak, 1976). Pupils placed in egg-crates are considered, as Immanuel Kant observed, "merely means" and consequently advocates of systematic education prefer corporate metaphors, referring to teaching as learning management. Corporate aims are outlined so that exclusively systematic approaches favour monolithic educational systems with uniform materials and hardware, with uniformly trained teacher/managers marketing uniformly trained graduates. . . . It transfers dead metaphors or established concepts, but does not encode new ones. . . . Systematic education cannot induce new ideas and practices because it demands that all learning follow rules and contingencies in a word, objective. All this has led us to consider excessive intellectualizing and rationalization as superior ways of meaning generation. The holistic perception which is decidedly superior to fragmentary outlook is discouraged. Intuitive wisdom, intuitive realization, and intuitive insight which, according to Indian tradition, are means to salvation and identical with freedom, are hardly emphasized. The sophistries of the intellect are, according to Buddha, hindrances to the higher life. In early Buddhism, *prajna* or intuitive insight represents the highest activity of the human mind. Radhakrishnan (1967) brings to our notice that Buddhaghosa makes *prajna* or intuitive insight superior to *vijnana* or logical knowledge and *samjna* or perceptual knowledge. And all these are hardly developed or respected in education. Gardner (1973), discussing the current crisis in education, asserts: What tomorrow needs is not masses of intellectuals, but masses of educated men—men educated to feel and to act, as well as to think. He quotes Yeats approvingly:

> God guard me from those thoughts man think
> In the mind alone;
> He that sings a lasting song
> Thinks in a marrow-bone.

The current tendency to celebrate the unthinking marrow-bone is as dangerous as the exaltation of the antiseptic mind. Education, which is the development of mind and attitudes in the young, is split into two grotesque parts—unfeeling knowledge and mindless arousal (Scheffler, 1977). This, of course, is really sentimental foolishness. Fragmentation, rather than integration, is deliberately encouraged. There is hardly any regard for what is expressed in the phrase *Bhumeva Sukham, Nalpe Sukhamasti:* happiness lies in totality, not in fragments. Therefore, it is observed that education has mainly celebrated the functions of the left cerebral hemisphere at the expense of the other side. Right cerebral functions have been demeaned. Education has unjustifiably taught children only one way to truth, ignoring that it is a double road—the road of analysis, and of what may be called intuition. Richard Livingstone (1952) writes in his characteristic style:

> To the injunction, 'Teach your pupil to think', I should like to add a further injunction, 'Teach your pupil to see and feel.' The soul has two eyes and both need developing fully; if either is shortsighted, the vision is imperfect. There is the critical, analytical eye which measures and assesses and protects men from illusions and delusion. But there is also the eye which enables them to contemplate, enjoy, and adore. In our age concentration on minute and microscopic study often impairs its vision, and we live contented with our myopia, in a world unrealized because the organ which could see it is neglected and atrophied. We are like one-eyed people, congratulating themselves on the vision of their single eye. But in

> everyone the poet should keep company with the rationalist: then we have the highest type of educated man. In our age and education the rationalist is apt to crowd the poet out, and in consequence we unconsciously lose the power of discerning realities which must be taken into account if our philosophy of life is to be adequate to the facts.

Education should match the children's level of neural development. The recent discovery that a child is developing not one but two cognitive systems implies that an optimum learning environment must challenge each of these systems. The question is not whether education should attempt to develop either the left or the right hemisphere, but that it should concentrate upon the development of neurological symmetry. To neglect the one in favour of the other is to be pedagogically naive. Effective education results from a fully acknowledged commitment to the functions of both cerebral hemispheres. Education has to acknowledge and celebrate, as did Jonas Salk, the fullness of the human mind. Richmond (1975) pleads for such a celebration:

> Whatever form the dualism takes—Locke's 'sensation' and 'reflection', Polanyi's tacit knowledge and explicit knowledge, Freud's conscious and unconscious, verbal and non-verbal communication, or the physiological dualism of the neo-cortex and the limbic system—the dualism can only be resolved by invoking some principle of interplay. If the brain is the powerhouse of the mind—womb is a better metaphor—it is because vital ideas are instinct with a life of their own, begot, as babies are, in the intimacy of a flesh and blood discharge.

To realize this, perhaps confluent education which advocates the beginning of a new paradigm can be of immense value. It, in fact, pleads the role of the left brain as it does of the right brain. "We need empirical, analytical, linear and rational kinds of thinking and brain functioning, but this, I repeat, must be integrated with the special, invaluable contributions (holistic, function-related, spatial, and perhaps intuitive) that our right brains can make (Rubin, 1979). Analysis, appraisals, and critiques as conventionally conceptualized are left-brain functioning. My reservation is simply that, as valuable as they may be, they are insufficient in and of themselves when accepted as an exclusive way toward the betterment of teaching. We, therefore, propose that we somehow integrate this nebulous, illusive metaknowledge with the more rigorous, empirical and analytical methods with which we are so familiar. But how do we put these two together? How can we find standards or agree upon measures that provide the objective or reality that we treasure so dearly in our empirical and scientific methodology? Of course, such objectivity is a myth unto itself. Michael Polanyi in his work on personal knowledge, Roger Williams in his descriptions of the distortions and abuse of data in biochemical individuality and the history of science itself, in which personal biases and prejudices govern the behaviour of the practitioners of science, provide strong support that science is, in itself, a belief system like many other mythologies. We can no longer consider that the right-brained creativity, intuition, metaphorical or holistic thinking have to fall within the province of soft-thinkers, dogooders, idealists, or those who emphasize "frills" in education (Rubin, 1979).

Confluent education, backed and supported by some highly individualistic innovators, has been described and worked out but with different approaches. The thin glue that holds them together is the notion that the integration of affective and cognitive process in the learning experiences is a highly desirable, potentially real, but seldom practised state of affairs. Some of the pioneering efforts in this direction are made by such notables as Abraham Maslow, Alexander Lowen, Carl Rogers, Frederic Perls, George Brown, George Leonard, Ashton-Warner, Gloria Castillo, and Gerald Weinstein. Various models have been suggested on the basis of extensive practical experience. The models in education attempting at such a confluence have been worked out by Shiflett (1975), Jones (1972), Tagore (Mukherjee, 1962), Maslow (1971), Castillo (1974), Lyon (1971), Yeomans (1973), Brown (1978), Eisner (1979), and Samples (1976). Aurobindo also, in distinguishing the four layers of mind or *antahkarana* and stressing the development of intellect or *buddhi* as being the most important for the educationist, advocated in 1910 a system which involved integration and confluence. Based on these educational philosophies, speculations, and practices, educational paradigms considering new understandings regarding kinds of knowledge and different epistemologies (see Smith, 1982) have to be worked out. This is because as Peter Abbs (1982) maintained in his reflections:

> It would seem that we have reached a historic moment of transition from an exhausted paradigm to a new broader paradigm now in the making, with all the confusion and uncertainty and turmoil that attends such making. The new paradigm is, in part, a creative response to all the ethical, existential and ecological dilemmas which have accumulated largely because of the defensive narrowness of the traditional epistemology. We have arrived at that volatile moment when the significant intellectual minority (both in the West and in the Soviet Union—in Sakharov and Solzhenitsyn) cannot only see through limitations of the post-Renaissance world-picture, but can also begin to formulate and defend what has been for so long excluded. What we see, in fact, is not a denial of the previous intellectual commitments (for, yes, we need both inductive and deductive methods) but rather a remarkable expansion of our understanding of the kind of knowledge open to human beings; an expansion which gives due appreciation to deeper forms of knowing—ethical knowing, aesthetic knowing, personal knowing, imaginal knowing. This sudden reclaiming of lost forms of knowing is on such a momentous scale that it does not merely modify the traditional paradigm, it transforms it. We are taken into new philosophical ground—and the ground is so rich and so prolific that it will take decades to harvest the fruit or, to put it conceptually, to explicate for education and society and, not the least, our own personal lives, the innumerable implications.

APPENDIX

TABLE:* *Hemispheric Function*

Mode	Right Hemisphere	Left Hemisphere
SPEECH/AUDITORY/LANGUAGE	Left ear	Right ear
	Left space awareness (stronger)	Right space awareness (stronger)
	Spatial orientation Spatial localization	
	Non-verbal Symbolic aspects	Verbal Grammatic logic Syntax
	Tonal qualities Tonal patterns	Analyses speech sounds Syllable recognition Analyses phonemes
	Tonal memory	Verbal memory
	Singing (pitch, rhythm, intonation, and lyrics) Musical hearing Melody	Phonics
	Holistic/gestalten Simultaneity	Word parts
	Emotional aspects	Spoken words Gesturing of hands Motor aspects
	Spatial words Nouns	Naming of objects Use of verbs Nonsense words Nonsense sounds Printed words and letters
	Creative language	
		Middle class

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*From Kane and Kane, 1979.

(Contd.)

Mode	Right Hemisphere	Left Hemisphere
VISUAL		
	Left visual field Left eye movers	Right visual field Right eye movers
	Spatial orientation Finding way Location of points in two dimensional space Depth perception	Labels space
	Holistic/gestalten Simultaneity	Parts of space
	Geometric form recognition Drawing	Notes detail
	Model building (from plan or picture)	
	Recognition of faces	Naming faces
	Creative	
		Sees printed words and letters Labels seen objects
MOTOR		
	Left side of body	Right side of body
	Spatial movement Finding way in space Front and back space awareness	
	Left tactual Braille skills tactual	Right tactual
	Simultaneity of movement Motor learning	Differentiated movements
	Drawing Model building	

Mode	Right Hemisphere	Left Hemisphere
	Movement memory	Verbal expression of movement through memory
	Creative movement	
		Action words (verbs) describing movement
		Movement of hands in speech
		Spoken words
		Motor activities of speech
THINKING	Deductive	Inductive
	Divergent	Convergent
	Holistic/gestalten	Parts/segmented
	Diffuse	Focal
	Intuitive	Logical
	Creative	Analytic
	Simultaneity	
	Visual-spatial Directionality Localization	Verbal
	Concrete	Abstract/symbolic
	Emotional thought	Rational thought
	Urban poor (spatial/ holistic)	Middle class (verbal/ analytic)
	Geometric organization	Mathematical reasoning
	Simple math computation	Abstract math computation
	Relational concepts	Sequencing of concepts
	Geometric	Algebraic
AFFECTIVE	Emotional	Intellectual
	Body image	Body concept
	Awareness of personal disabilities	

(*Contd.*)

Mode	Right Hemisphere	Left Hemisphere
AFFECTIVE	Intuitive	Logical
	Recognition of faces	Remembering names
	Tonal expression Simultaneity Laughing Crying	
	Passive	Aggressive
SEXUAL		
	Feminine Passive Mysterious	Masculine Aggressive Active
	Artistic aspects Intuitive aspects	
	More specialized in males	More specialized in females

TABLE : * *Review of Literature related to the Functional Organization of the Hemispheres*[1]

Left Hemisphere	Right Hemisphere	Investigators	Year
Verbal:			
Writing		Brandwein and Ornstein	1977
Verbal		Olson	1977
Language (age 5)		Calearo	1975
Verbal		Dumas	1975
Language		Epinas	1975
Language (age 5)		Harris	1975
Verbal-numerical		Gallaway	1975
Verbal-numerical		Doyle	1974
Speech		Nebes	1974
Language (age 5)		Pincus	1974
Speech		Sperry	1974
Speech		Eccles	1974
Verbal-numerical		McKee	1973
Verbal-numerical		Morgan	1973
Writing		Luria	1970
Language		Kimura	1967
Verbal (VSIQ)		Guertin *et al.*	1966
Language (98%)		Penfield and Roberts	1959
	Limited language (pitch perception)	Van Lanker	1975
	Metaphoric expression	May	1977
	Limited language	Geschwind	1970
	Metaphoric expression	Samples	1975
	Metaphoric expression	Ornstein	1972
	Limited verbal (with adequate time)	Gazzaniga and Hillyard	1971
	Limited verbal	Nebes and Sperry	1971
	Limited verbal	Lenneberg	1967
	Limited verbal	Luria	1966

*From Rubenzer, 1978.

[1] Functional organization, in essence, is where certain processing functions (e.g., language processing) are hypothesized to be localized in the cerebral hemispheres.

(Contd.)

Left Hemisphere	Right Hemisphere	Investigators	Year
	Limited verbal (with adequate time)	Bogen and Gazzaniga	1965
	Limited verbal	Weisenberg and McBride	1935
	Language	Jackson	1866
Non-verbal (visual):			
	Spatial	Brandwein and Ornstein	1977
	Spatial	Olson	1977
	Spatial	Hunter	1976
	Spatial	Goyvaerts	1975
	Spatial—males more adept	Harris	1975
	Spatial	Schwartz	1975
	Spatial	Dimond and Beaumont	1974
	Spatial	Kimura	1973
	Spatial	Milner	1971
	Spatial	Knox and Kimura	1970
	Spatial	Benton	1969
	Visual-Nonverbal symbols	Zangwill	1961
	Visual-Nonverbal symbols	Humphrey and Zangwill	1951
Nonverbal (auditory):			
	Music	Buffery	1976
	Music	Entus	1975
	Music	Molfese	1975
	Music	McKee	1973
Nonverbal (sensory):			
	Tactile (touch)	Epinas	1975
	Bodily orientation	Hecaen	1975
	Bodily orientation	Warrington and Rabin	1970
	Aesthetic	Hebb	1966
	Aesthetic	Hadamard	1945
Cognitive styles:			
	Creative	Torrance	1978
Analytic		Brandwein and Ornstein	1977
Acquiring new habit patterns		May	1977

Left Hemisphere	Right Hemisphere	Investigators	Year
Convergent, rational linear	Divergent, holistic	Perrone and Pulvino	1977
Convergent	Divergent	Bongen	1976
Logical		Dilling	1976
	Intuitive	Garrett	1976
Logical		Kraft	1976
	Approximate knowledge	Prince	1976
Differentiated—Controlled		Epinas	1975
	Analogic-Divergent	Samples	1975
Sequential—Logical	Holistic	Papcum *et al.*	1974
Analytic		Sperry	1974
Analytic	Analogic	Salk	1973
	Intuitive	Rennels	1972
	Creative	Tart	1972
Sequential—Temporal		Luria	1970
	Creative	Bogen	1969
Convergent		Wallach and Kogan	1965
Discrete	Diffuse	Semmes *et al.*	1960
Education of relations	Education of correlates	McFie and Piercy	1952
Educational content:			
Writing		Brandwein and Ornstein	1977
Algebra	Geometry	Hunter	1976
Reading/Math		Sperry	1974
Math		Nebes	1974
Writing		Luria	1970
Math		Day	1964
Affect			
Positive	Negative	Dimond *et al.*	1976
	Negative	Janes	1976
	Affect in general	Ornstein	1972
Affect related to consistency	Affect related to aesthetics	Hebb	1966
Affect related to consistency	Affect related to aesthetics	Hadamard	1945

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PART II

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Neurosciences and Education*

ROBERT B. LIVINGSTON
University of California

The human brain is a recent product of evolution. It is still evolving. Genetic evolution is slow because it depends on direct lines of ancestry. Cultural evolution is rapid because any wisdom or knowledge acquired by men can be rapidly and widely diffused. Creativity may be considered along an extended scale from the humblest individual learning experiences to the catalytic contributions of the greatest geniuses. However, the brain remains an incompletely exploited instrument for further evolution. As for education, although it is at a crossroads, much can be done, if we only manifest our will.

Social progress has been occurring, but it is uncertain at this time whether man's knack for tinkering with things, as *Homo faber*, will foreshorten or eliminate long-range opportunities for the flowering of his potential wisdom, for man's living up to the promise of becoming truly *Homo sapiens*. Slavery has generally been diminishing. Racial and religious tolerance was for centuries considered contrary to any reasonable concept of morality. Epileptics and the insane were incarcerated and beaten for their own good and society's. Lightning-rods were condemned as an impious attempt to defeat the will of God by assisting criminals to escape. Vaccination and anaesthesia were abhorred on moral grounds as being contrary to nature.

It may give us comfort to remember that the only period of history we are obliged to face is our own. It remains to be seen whether we can meet the main requirement of our day—the resolution of conflicts by means other than war, by means that promote justice and individual self-determination. War is the chief stupidity of man, seen from any viewpoint. Creativity is the most promising avenue for continuing to discover constructive alternatives for the resolution of conflicts. These problems are deeply rooted in contemporary processes of perception and judgement.

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*This article was written for a series of studies prepared for the International Commission on the Development of Education, at Unesco. We are publishing large extracts of it here.

Perceptual skills develop just as do motor skills. One is private, the other public. Each takes about as much effort for retraining and adaptation to new circumstances. Because perception is private, it is less exposed to the need for its revision. The way we perceive things and the language we use to communicate with each other concerning our perceptions are interdependently related.

If we better understood the biological and cultural mechanisms affecting perception, judgement and action, we would probably become more willing to be tentative about our differences, better able to tolerate ambiguous situations with equanimity, better able to sort out constructive means for adapting to change, more empathic and cherishing toward differences of individual and cultural experiences and interpretations. We would become more adept at grasping features of the world that do not now correspond to our still limited world view. We would better realize that processes essential to maturation of the individual, group and society—processes essential to the evolution of mankind in the direction of wisdom—depend on our working out, against whatever difficulties confront us, improved, more inclusive, but always tentative views of the physical, biological and social world around us. Education is at present designed mainly to help us know better how to live in a narrow part of the world, locally perceived. Education needs to be cultivated on a truly international scale, to help us learn better how to be creatively and constructively adaptive on spaceship earth—how to conceive, test and utilize new, more comprehensive assumptions about the world and about the questing, probing, venturesome human brain. Education is indispensable for the next steps for man.

WHAT SORT OF THING IS THE HUMAN BRAIN?

The human brain weighs one and one-half kilogrammes (3.3 pounds) of which more than 80 per cent is water. Half of the remainder is fat; the other half is a mixture of carbohydrates, proteins and nucleic acids. These substances are organized into a watery matrix that constitutes the most complicated mechanism known to man. The brain contains scores of billions of nerve cells which form a skein upon whose tendrillar projections dance nervous impulses that define for each of us a personal world, maintaining our visceral housekeeping, banking our memories, governing our comportment, and reckoning our pains and pleasures.

A Comparison with Computers

In order to grasp the significance of brain complexity we may compare its componentry with that of modern computers. Engineers are devising microelectronic circuits that are being made smaller, more economical and more reliable. In laboratory conditions, they can now construct decision-making devices that contain several hundred thousand 'yes-no' switches per square inch. These are photo-etched on flat microchips. It is hoped that by 1980, engineers may be able to build similarly compact circuits, but in a three-dimensional volume. If they are successful in this, the concentration of switches will still be one-twenty-fifth as compact as the density of nerve cells in ganglionic masses of the human brain.

The connexions of such electronic devices are at present necessarily stereotypical whereas enormous connexional subtleties exist in brain organization. Each nerve cell receives from ten to ten thousand or more synaptic contacts from upwards of tens to thousands of different neurons. This battery of space-time inputs becomes coupled with the spontaneous activity of the neuron itself which has a variable set-point. The result is that the neuron emits a computed response which, by a variety of neuronal codes, delivers its influence to tens to thousands of other neurons lying nearby and remotely disposed. The neuron deals in unimaginably more comprehensive and variable operations than the components of computers. It is a miniature computer in its own right.

For a computer to operate a number of 'yes-no' switches equal to the number of neurons in the human brain would require the waters of Niagara Falls to prevent overheating. The human brain does its work quietly, in a recognizable compact space, and with a power consumption of only about twenty watts.

A Potential Avalanche of Nerve Impulses

A further illustration of the potentialities of the human brain was contrived some years ago by C. Judson Herrick. He estimated that a single flash of light to the human eye could induce a barrage of impulses among neurons along the visual pathways which, using minimal assumptions of contacts between neurons in the visual cortex, would yield an horrendous number of ultimate potential transactions. Herrick estimated these to be, conservatively, $10^{2,783,000}$! If we recall that the total number of atoms in the universe is less than 10^{100}, we realize that the potentialities for impulse distribution within brain circuits will remain beyond imitation by engineers for some time.

It remains for men to utilize their own brain power for the creative processes of discovering improved options for social progress. Computers can be immensely useful in the experimental testing of these options and by extending man's brain capabilities for relatively stereotypical computations.

Distinctions between Genetic and Acquired Brain Characteristics

In part our brains are designed for us according to our genetic inheritance. But the aspects of brain function characterizing human behaviour, those relating to social transactions, are largely acquired during our lifetimes. The genetic framework which we inherit for the initial structuring of our brains naturally depends strictly and exclusively on our individual ancestry. This plaited chain of inheritance is nevertheless remarkably individualized as a consequence of the chancy dance of chromosomes that takes place during sexual union.

This, of course, affects our inheritance at every stage all along the path of our direct ancestry. It is estimated that the possible combinations of different inheritable characteristics resulting from the combination of one pair of human gametes involves a variety that is greater than the total number of human beings that have existed since the origins of the hominid line. Individuality is therefore built into our genetic make-up. Since a large share of genetic instructions are involved in the organization, development and functioning of the nervous system, idiosyncrasy of human brain organization and operation is entirely normal.

Information contributed and skills acquired during an individual's lifetime of experiences produces some operational convergences and some divergences stemming from the enormous potentialities supplied at the outset by our genetic endowment. This individual shaping of brain processes is most rapidly instructed by the cultural system encountered during our infancy and early childhood. Although we can receive genetic instructions only from our own direct ancestral lineage, we can, through educability of our individual brain, embody contributions to the images, judgements and the techniques and scope of our thinking by enriching ourselves through contributions from men and events available from any place and any past time. We are instructed by Plato or Confucius, Goethe or Jiminez, Elizabethan theatre or Kabuki, Tolstoy or Mark Twain, Palestrini or Hindemith, Praxiteles or Cro-Magnon man, Van Gogh or Memling, Mohammad or Prince Gautama, Darwin or Einstein. The reach of our minds is limited only by the degree of internal drive, the initially established habits for acquisition, and the time and materials available. With new knowledge about motivation and learning that is emerging in the neurosciences and with modern techniques for reproduction and transmission of information, future generations should have increasingly generous opportunities.

Brain as a Self-Activated System

Our brains are not passive instruments to be played upon by our parents, teachers and others. The brain is self-actuating and self-governing. It is the hardest working organ of our bodies. Although it weighs only 2 per cent of our weight, it disposes of more than 20 per cent of our overall energy. Although by appearance it is flaccid and motionless, it works as hard metabolically as do the skeletal muscles of exercising athletes. The brain spends energy in this fashion day and night whether we are waking or sleeping for the duration of our lives.

What are the fruits of this industry? The conversion of oxygen to carbon dioxide, like any other organ, although at an unusually high rate, the utilization of sugars, and the turnover of astonishingly large amounts of proteins and lipids. Nerve cells are constructing proteinaceous materials at a rapid pace, presumably in the formation, alteration, and breakdown of membranes.

Examination of the fine structure of nervous systems reveals that they are composed almost entirely of membranes. Although we see these structures in a static form, fixed for convenience of observation, we must remember that they are not necessarily idle. Paul Weiss and Charles Pomerat pioneered in showing that, when nervous tissues are viewed with time lapse photography, there is evident a conspicuous microscopic motion of membranes and organelles, and bulk flow of neuronal contents. Like plants that are opening and closing, budding and sending out tendrils, the nervous system, on a microscopic scale, is similarly dynamic. The activity involves selective making and breaking of contracts between individual cells. We do not yet understand the implications of this microscopical activity and, for technical reasons, we do not yet know how activity of this sort might vary during various forms of brain function. The activity already visualized is of sufficient magnitude and universality to suggest that it might have important consequences for neuronal circuitry. The activity suggests that neuronal circuits may be intermittently strengthened and weakened, initiated or terminated perhaps in accordance with the traffic of nerve impulses along the involved pathways. It makes one wonder whence can arise any enduring functional stability? The answer is not available, but the emerging insight is one of far more plasticity and modifiability of nervous system mechanisms than was heretofore appreciated.

WHAT DOES THE BRAIN DO?

The Government of Goal-directed Actions

Our brains seem to be designed to govern actions. And the actions always seem to be goal-oriented, for the achievement of internal visceral satisfactions. Brains are built to 'hale the sullen slaves (e.g. our muscles and glands) along'. The touchstone of such commands stems from the flux of our internal physiological state. The goals of visceral satisfactions may be immediate and desperate, as in our response to an obstructed airway, or to an irresistible peristaltic wave: they may be less immediate but strongly compelling as in temperature regulation, thirst, hunger, sex, or sleep; they may be more remote and removed as in aesthetic responses or ascetic devotions. Satisfactions of this latter sort are acquired and indirect, as in the satisfactions derived from praise or self-control. Nevertheless, they all seem to relate back ultimately to visceral satisfactions. Even self-sacrifice is perforce of an inner satisfaction or escape from irrepressible dissatisfaction. Priorities for actions closely follow the flux of biological purposes and can be changed abruptly.

Three Motoric Functions

The nervous system, according to Paul Yakovlev, engages in three motoric functions. These are visceration, expression and effectuation. Visceration relates to the regulation and restoration of physiological growth requirements, endocrine and metabolic balances, respiration, blood pressure, temperature regulation, water and food intake and waste product output, accommodation to exercise, acclimation, cyclic changes associated with endocrine and sexual behaviour, sleep and arousal, etc. Expression relates to emotion—literally, e-motion, or ex-motion, the outward expression of our internal state. This includes bodily attitudes, orienting behaviours, social imitations, and approach and avoidance behaviours. Effectuation refers to what we do to change the material world around us, moving objects, assembling things, destroying.

What is performed by way of visceration is nearly universal although there are interesting social and cultural differences even in this sphere of visceral control. What is expressed by the nervous system is manifestly influenced by social and cultural traditions. A single individual usually plays several distinctively different roles of expressive behaviour within any given culture. Some of these roles are largely unconsciously acquired and manifested. What is done by way of effectuation is almost entirely acquired and is strongly dominated by social and cultural experiences. Effectuation is to a considerable extent dependent upon conscious awareness and yet it can be considerably habituated. If so, it may be more interfered with than helped by direct conscious intervention. Golfers tell us this is so!

Education in relation to Motoric Functions

Education, in the informal sense, has to do with all three realms of motoric function. Formal education, in many cultures, has been dedicated largely to shaping the skills of effectuation. Depending on the given culture, however, the aims of formal education may emphasize preponderantly influencing things or influencing people. Both thing-oriented skills of effectuation and people-oriented skills of expression are universally deeply embedded in informal education.

Subjective Experiences

We deliberately left aside until now the treatment of subjective outcomes of brain activity. Starting with motoric functions and proceeding thence to subjective functions is contrary to the usual expository practice. Usually sensory stimuli and mechanisms of perception are dealt with first and motor activities are treated as reaction systems. This conception makes good sense from a point of view outside the subject individual. But it is perhaps more appropriate, in the context of education, to recognize that in the beginning there is feeling and action stemming from internal sources, and only later is there attachment of outside stimuli to those sources of feelings and to higher order (above reflexes) commands effecting activity. This is true for the development of the infants' awareness of body image and growth of sensory-motor skills. It is equally true for adults learning a skill. Even reflex responses, as have been increasingly clearly recognized in recent years, are heavily dependent on the dynamics of the internal state.

It appears that both throughout evolution and during development of the individual the priority for subjective awareness has been to improve prognostications essential for successful actions, the success being measured ultimately by internal satisfaction. Consciousness was postulated by George Coghill as emerging in evolution and during development from crude sensations of effort and duration. Feeling, mood, sensations of tension and fatigue or playfulness seem to be dependent upon internal well-springs over which we have little control and which we can disguise only transiently. We can take an immediate reading by introspection, and sense confidently anytime in our waking hours just what is our internal feeling state, our mood, etc. We can easily make a self-rating evaluation of our 'level of happiness' or 'sadness', 'restedness' or 'fatigue', etc., on a scale of one hundred, although we would find it difficult to describe of what components the assessed feeling consists.

Primitive Sensations—Olfaction and Pain

Olfactory sense and pain sensibility appear to have no representations in neocortex. Neocortex is in evolution the most recent cortical development, appearing only in mammals. Both olfaction and pain are in quite direct communication with our inner feelings. It is difficult to be precise about olfactory and pain experiences in terms of language. The highest olfactory projection is to phylogenetically old cortex, mesopallium. Pain is represented mainly in brain stem systems close to our innermost subjective feelings and relatively remote from higher analysis and explication.

Discriminative Sensations

It is only when we study some aesthetic senses such as discriminative touch, vibratory and position sensations and auditory and visual perceptions that we find a subjective representation that can, with experience, be given quite precise linguistic or notational definition. These sensory pathways have abundant neocortical representations. These sense modalities also have access by way of collateral projections to influence our feelings and moods. The more readily subjectively analysed and defined parameters of visual and auditory sensations belong to some superordinate system riding with and on top of the more primitive viscerally directed sensory messages.

Perception depends on Past Experiences, Expectations and Purposes

The important lesson of subjective analysis is one that is drawn from the work of Adelbert Ames Jr. and Hadley Cantril and their followers. What we perceive depends critically on our internal state, on momentarily obtaining physiological conditions. These include the visceral state of well-being or distress. They include also prognostications for action—prognostications that are necessarily based on our complicated past history of witnessing similar stimuli. From these past experiences we automatically develop 'weighted averages' that dictate our prognostications. What does all this mean? It means that we do not perceive what is 'out there'. We perceive, instead, events inside our brains which are composed of the following: the results of stimuli which activate our sense organs and sensory pathways, including transmissions into and among higher cortical and cortical association areas and other centres; at the sense receptors themselves and at each centrifugal relay of signals there are transductions which depend in part on local intrinsic 'spontaneous' nervous activity and also in part on centripetal sensory 'comparison' impulses generated and controlled centrally; the combination of centrifugal and centripetal messages contribute the necessary linkages among memory stores, including impulses relating to our momentary state of expectation, and impulses relating to our momentary state of visceral needs. All of these processes take part in our perceptual experiences. Perception is therefore much more than just an invasion by sensory impulses. It is an active process in which the perceiver is automatically engaged and precommitted.

Ames' Demonstrations

Perception is therefore a neurologically complicated process. It incorporates active perceptual skills that are acquired during early development and that continue thereafter to be only moderately modifiable throughout the remainder of one's lifetime. There are assorted stable perceptual habits, heavily weighted averages, formed early in life, which tend to have strongly compelling influences on future perceptions.

An example demonstration by Ames: a trapezoid, painted like a window, when rotated slowly, appears to oscillate, apparently presenting one edge only which swings back and forth as long as the trapezoid is rotated. A bar suspended from the mullions of the 'window' appears to bend and snap into a new position with each rotation, or to cut through the mullions and appear on the other side. A cube attached to one corner of the trapezoid seems to detach itself and 'orbit' through half of the cycle and then accompany the corner through the other half. It can be shown that this is not a simple 'optical illusion' because it is seen correctly, that is, as a rotating trapezoid, by children up to the age of about 8 or 10 years. It is also seen correctly by adults who have not lived in a predominantly rectilinear architectural environment, e.g., Zulus. It is evident that the habitual perception of rectilinear architecture intervenes in the perceptual interpretation of an object that resembles a window, door, room, etc., but is not itself rectilinear. Many other similar examples are available.

Ames and his followers constructed distorted rooms which compel an illusion of laughable distortions of objects and people. Persons standing at the far corners of the room appear to be of twofold difference in height, but when they exchange places the larger individual shrinks in half and the smaller one doubles in size! This biological improbability is produced by our past perceptual experiences. Size-brightness discrepancies, distance parallax and overlap, size-distance relationship, hardness, resiliency, and a wide variety of other body wall, auditory and visual perceptions are similarly demonstrably conditioned according to our past experiences. Ames and others have also demonstrated that perceptions are conspicuously affected by expectations; for example, how much of what is perceived can be modified by instructions and prior conditioning. These can also be vastly affected by the testimony of other witnesses. Perceptions are additionally affected by the perceiver's purposes, by the values he attaches to the object perceived and by the use he may intend for it.

The Dynamics of Ongoing Perception

Jerome Bruner projected out-of-focus coloured slides of common place objects to subjects who were asked to indicate what they thought the pictures showed. The projections were gradually brought into better focus. The process of making perceptual assumptions induced perceptual commitments which carried over to affect later interpretations until well beyond the point at which an 'outsider' could easily identify the same image correctly. The images could often be brought into perfect focus while subjects were still perceiving according to earlier committed assumptions that were ridiculously remote from the real object. This ties in with the effects of expectations on perception and illustrates the binding power of prior assumptions.

Other workers have shown that if four pictures are displayed simultaneously in a brief exposure, the images are perceived correctly or incorrectly according to the emotional content of each individual picture for a given subject. Thus, three pictures out of four may be correctly perceived, regardless of the arrangement of the four images on the screen. If the fourth is moderately 'taboo' emotionally for that individual, the subject may require several times more exposures and several times longer exposures in order to perceive this image. This suggests that in the comparison between stored images and present incoming impulses, there is an element of 'censorship' as well as all the other effects identified above.

The Kilpatrick Demonstration

An excellent illustration of the need to act out in an environment in order to perceive it correctly, and also of the perceptual commitments induced by past experiences, was provided by Franklin Kilpatrick. He built three small model rooms which could be viewed from the same chair. One model was distorted vertically, one horizontally, and the third was rectilinear. Subjects who are allowed to view one room after the other in any order report that the rooms appear to be similar and that they seem to be normally projected, i.e. rectilinear miniature rooms. Each subject is then given a probe and instructed to touch a mark on the left wall in the left-right distorted room. He reaches to where he expects the mark to be, but is surprised and startled by the fact that he needs to reach much farther than he expected. When he finally stretches enough to touch the mark on the left wall, he is asked to touch another mark on the right wall. His probe strikes the back wall and then the far end of the right wall. He must withdraw unexpectedly far back and still farther before he can place the probe on the mark. He is then instructed to proceed back and forth in touching the two marks one after the other. After a few trials, he suddenly perceives the model differently; he now perceives it more correctly, with left-right asymmetry. He has learned to perceive through acting out in the environment, something we all have to do for the development of all of our perceptual skills, from infancy.

An additional feature of interest in respect to the Kilpatrick demonstration is that after this conditioning experience, when the subject again inspects each of the three models, he reports them all looking alike, but now with 'left-right asymmetry'! He reports them all distorted in accordance with his recent perceptual acquisitions which in turn depended upon his acting out in a particular environment. We may surmise from these various convergent lines of evidence that individuals reared in distinctly different environments are bound to have distinctly different perceptions in many instances.

The Waterfall Effect

It has long been known that if you gaze for a few minutes at a waterfall and then turn your gaze to face the rocky cliff adjoining, you experience the startling perception of a section of the cliff (approximately the width of the waterfall) moving upwards in relation to the rest of the cliff! This effect has been imitated in many different ways in the laboratory. The after-effects can be accurately charted and measured. It has been shown that the waterfall effect cannot be due to eye movements; instead, it must reflect a newly adjusted prognostic programme for just that sector of the visual system that is obtended by the width of the waterfall.

Other Examples

Many people are familiar with the false perception, after a sea voyage, of instability of the wharf, solid ground, the floor, chairs, and bed. The French call this *mal de débarquement*. The perception of continuing motion may last for several days and may recur even after it has largely subsided, when one tilts one's head in an uncustomary position. Accompanying the perception is a wide-stanced gait, 'sea legs'. Some people may become sick and vomit only after getting to shore, particularly if the roughness of the voyage increased gradually. It appears that during shipboard experiences we 'learn' to prognosticate motion which, in its aftermath, continues to accord well with the characteristics of the wave and ship motion experienced. Some people have noticed that after driving fast in an open car for a few hours, there may be a sustained perception of hair or whiskers blowing. If the car is closed, and only one forearm is exposed to the wind, the after-perception is limited to that region. Some individuals have a vivid visual impression, after having driven some hours, of the road continuing to advance. This may be perceived even with the eyes closed. Riding while facing the rear from the back of a car or train platform is an unusual enough experience to generate special perceptual effects while beginning to travel in that way—hills, for example, appear abnormally steep; after a while this effect disappears, but after stopping such travel, objects in the visual field appear to be expanding. This is a perceptual prognostication dependent on some hours of experiencing objects getting smaller because they are receding.

Each of the above examples emphasizes the plasticity of our perceptual apparatus. They indicate also that we depend upon sensory motor combined learning in order to be able to perceive. We learn to perceive. Present perceptions are correlated automatically with stored experiences. We shape current perceptions according to previous perceptual outcomes. An important point is that if there is a discrepancy between sense stimuli generated from the outside and stored experiences, the stored experiences dominate. The overwhelming subjective effect is the compelling sense of veridicality generated by the stored experiences. We understand thereby how powerfully past perceptions become committing for future perceptual prognostications, we become automatically and unconsciously committed to habitual perceptions.

Perception as a Goal-Seeking Process

Seen from the point of evolution and of development of the individual it is obvious that those perceptions which have in the past led to visceral satisfactions and to the avoidance of visceral dissatisfactions generally have survival value. And they certainly tend to acquire strong like and dislike values for the individual. Perception is thus organized for successful motor performance and has no other biological foundations. We encounter trouble, however, when we assume that our perceptions have intrinsic epistemological significance, when we believe that what we perceive 'out there' actually exists 'out there' in the form in which we perceive it. In the course of development, as our actions prove the limitations of previous perceptions for successful prognostic purposes, our perceptions are gradually amended. This process of perceptual error reduction, in a given context, becomes so strongly reinforced that when we encounter a situation that is different, our past perceptual prognostications nevertheless dominate and we make further errors. These errors may be grave, as when a hunter perceives a deer and thereby accidentally shoots a man. They are important in another respect—errors represent one if not the only opportunity we have for learning.

Seen from the point of view of society, there are two major effects of these learning-to-perceive processes. The first is that people sharing similar past experiences tend to make the same misperceptions and, therefore, tend to confirm among themselves the similarity (and hence presumed veridicality) of their perceptions. This tends strongly to stabilize shared community perceptions. There may be few opportunities for error correction by action. Novelty, particularly encountered in cross-cultural transactions, may be widely misperceived by each of two groups, while each is receiving strong intragroup stabilization of its own idiosyncratic misperceptions. The outcomes of such conflicting prognostications may be bilaterally charged to malfeasance rather than recognized as due to culturally different past experiences.

Nobody has access to the outside world except through such experience-bound perceptual processes. Everyone is strongly suffused with confidence of the veridicality of his own perceptions. These biological mechanisms thus have the effect of precipitating and amplifying conflict. The likelihood of conflict, of course, increases with disparity of upbringing. Under given circumstances, neither party to such a conflict may be guilty of any wrongthinking or wrongdoing. It is simply that the events, as perceived, may have been categorically different. This is equivalent to the two individuals perceiving different events, of existing in different worlds. Because many of these effects are taking place during input stages of their perceptual processing, before these can be available to consciousness, the discrepant perceptions are perceived as absolutely incontrovertible facts to which are added the momentum of intragroup reinforcement and intragroup sanction.

It is not difficult to realize that some unknown proportion of the world's conflicts, among individuals, communities and nations may be wrongly assigned as deliberate malfeasance. To the extent that this process can be better understood and more widely communicated, it should provide an opportunity for growth and maturation of mankind, for a reduction of present risks, and for a closer approach to *Homo sapiens*.

Cultural contributions, through formal and informal education, are obviously both critical and overwhelmingly powerful in affecting these naturally existing biological conditions. Education can work strongly in the direction of worsening or in the direction of reducing international risks according to local cultural disposition.

INTERPRETATIVE FORMULATIONS

The nervous system consists of a matrix of dynamically active, excitable membranes and associated chemical processes. Neurons and glia are organized into circuits and systems that link up with one another to effect sensory-motor control throughout the body and in relation to the outside world. The human brain is the most complex mechanism known to man, but it is already being sorted out in ways that are recognizably meaningful for education.

Brain functions involve simultaneous, mutually interdependent signalling transactions occurring among billions of spontaneously active cells that balance each other with feedforward and feedback regulations. Operation of the body as a whole depends upon the brain's internal control and neuroendocrine systems control provided by diffusely projecting neuronal circuits. The first nervous systems were diffusely projecting, and all later evolutionary inventions have built upon this holistic, integrative scheme.

The natural history of nervous system evolution and embryogenesis indicates that brain organization and activity is designed to secure visceral satisfactions. Visceral assessment properties are built into the nervous system and embody directional forces which tend toward survival of the individual and survival of the species. Visceral satisfactions are the biological foundations of all human goals—no matter how aesthetic and long-range.

Mammals, and particularly primates, developed successful biological mechanisms to sustain prolonged infant dependency on the parental generation. Both generations derive distinctive visceral satisfactions from this interacting. These indispensable interdependent satisfactions emerged through evolution as a part of more general nervous system traits governing co-operation, mutual trust and altruism. Specific behavioural characteristics of infant and parental relationships are acquired very early in life: lack of appropriate experiences in infancy precludes successful adult sexual and parental behaviour.

Hominid departure from the common ancestor of all primates was characterized by birth of an even less mature and more dependent infant. Evolutionary pressures for increasing the brain size became effective mainly after birth. Over less than one-tenth of 1 per cent of the total span of evolution, adult hominid brains expanded more than threefold, mainly by rapid growth and elaboration of the brain during infancy. The lengthening period of infant dependency combined with luxuriant brain development became, increasingly, a period of tutelage and apprenticeship, of learning and acculturation. This probably accounts for the fact that early man was the first species in evolution to learn (and teach) living practices adaptable to all climates of the world. Brain growth is attributed to a combination of changes including upright stance, prehensile thumb, object play and object manufacture, increasing social communication, etc. Intellectual and cultural developments likewise contributed to brain enlargement during evolution.

Modern man appeared about 50,000 years ago, already showing cultural distinctions among his art forms, burial practices, and tool and weapon manufacturing. All of this required substantial and prolonged educational programmes, and it probably also required elaborate language. Expansion of utilization of gesture vocalization presumably led to the naming of objects and this in turn to the giant step of creating the cognitive gymnastics and conventions necessary for communication by sentences. Language is closely allied to perception and tends to bind perceptual and judgemental inferences in accordance with its intrinsic and culturally idiosyncratic logic, values and metaphors. Language becomes conspicuously limiting as well as enabling, for thinking and remembering processes, making them differentially culturebound.

The genetic flexibility of sexual union provides more potentialities for genetically distinct offspring from one human couple than the total number of human adults that have existed since the advent of the human species. Embryonic organization and development of the brain is very rapid throughout gestation and it is critically dependent on adequate nutrition, especially protein. The child is born with a full quota of brain cells but these are not all in final position and the vast majority of them are very incomplete in terms of branchings and ultimate attachments. The brain doubles in size during the first six months of life and doubles again by the fourth year. During this critical period, cell growth and feature elaboration continues at a high rate and the infant remains critically dependent on tender, loving care, proper tutelage and an adequate diet.

During infancy, the child is characteristically congruent and promptly responsive to his visceral needs and satisfactions, presumably being dominated by hypothalamic and brain stem controls. During maturation, the child's growing capacity for emotional experience and expression, social imitation, and simulation, and, ultimately, long-range postponement of visceral goals, can be understood as expanding in parallel with development of the limbic system, basal ganglia and frontal lobes. Not only are sensory-motor skills learned, perception itself must be learned by taking action. This inevitably occurs in a particular environment. This experience leads to habituation of perceptual inferences that are demonstrably peculiar to that environment.

The brain is built for action. Nerve cells in general are spontaneously active and the set point of their spontaneity can be modulated by specific and generalized signals introduced by near and remote events throughout the brain. Nervous system output consists of muscular and glandular activities categorized as visceration, expression and effectuation. The former are controlled predominately by neuro-endocrine, hypothalamic and brain stem mechanism acting in concert. These processes are generally unconscious, but they may break into consciousness at any time and override all other purposes and programmes for comportment. Cortical representation of visceral functions and the experiencing and expression of emotions is mainly attributable to the phylogenetically primitive limbic system. Expression is further controlled by an ensemble of the limbic system, basal ganglia and frontal lobes. All of these interact with each other and converge on the hypothalamus and midbrain.

Social imitation and social signalling, a large part of education, utilize mainly the basal ganglia together with the brain stem. Effectuation is achieved predominantly by neocortical systems that find their outlets through pyramidal, basal ganglia and brain stem systems. All three of these major categories of motoric control are conditionable. All three are affected during conditioning by idiosyncratic individual and cultural experiences that are intrinsic to any given environment.

Perception consists of conscious prognostications for action. Prior to their emergence into consciousness, sensory signals are explicitly shaped according to an individual's past experiences, expectations and purposes. The final result is a matter of 'weighted averages' together with some shielding by selective censorship. Olfaction and pain are primitive sensations that influence behaviour relatively directly without neocortical representation. Discriminative sensations reach neocortex and are available for symbolic, including linguistic, analysis.

Perception is an active neurophysiological process that involves comparisons with memory stores during preconscious recognition and evaluation. A share of the shaping of sensory signals into perceptions involves centrifugal impulses that provide central control of sensory receptors and sensory transmission systems. Centrifugal as well as centripetal sensory controls are subject to conditioning. Perceptual phenomena indicate unambiguously that perceptions as experienced are already dominated in accordance with idiosyncratic and culturebound past individual experiences. Many compelling effects take place before the neural events become accessible to consciousness. Thus, to the degree that the preconscious perceptual controls in different individuals are differentially conditioned, those individuals will perceive the same event as two different events. Both experiences will be subjectively convincingly veridical.

Perception, contrary to commonplace assumptions, is learned. The experience of correlating visual and bodily activities is essential to the recognition of both body image and the spatial dimensions of the environment. Perception is learned initially and corrected throughout life in no other way than by acting out in specific environments. Because of the shortness of life, an intimate acquaintance with more than a few environments is impossible. Because conspicuously different perceptual experiences are associated with different environments, different perceptual inferences become ingrained. A number of these, sufficient for illustrative purposes, have been identified and measured under controlled conditions. Habituated perceptual inferences are found to affect the perception of even simple lines and objects and in complicated ways. It can be supposed, with justification, that if simple things are perceived so distinctively differently, there are likely to be even greater gulfs, perceptually, between different individual and cultural experiences involving more complex perceptual events. There is evidence that this is dramatically true for the interpretation of different languages and for other complex perceptual and cognitive functions.

People who share given experiences tend to habituate the same perceptual inferences. Therefore, there is a powerful and seductive trend toward in-group stability of perceptions, judgements and actions. When individuals belonging to such a group refer to each other for testimony they tend to confirm and to stabilize the already strong individual subjective experiences of verisimilitude of their perceptions and to confirm among themselves the erroneousness of any testimony to the contrary. What is considered 'right' and 'loyal to the group' can become a self-reinforcing and ingrown vortex that may obtain a persistent stability of its own.

Modern means of transportation and communication, and strong international competitiveness, bring people of significantly different past histories, expectations and purposes into conflict with one another. Processes of biological commitment of perception, judgement and behaviour tend to magnify any intrinsic difficulties and to amplify all contrasts in points-of-view and values. Patriotism, narrowly pursued, naturally exaggerates this tendency. Because most people are unaware of the limitations of their own and others' perceptual processes and because subjective experiences accompanying perception are strongly veridical, the natural assumption taken in the face of conflicting testimony is (a) one or both of the participants in the conflict must be lying, or (b) one or both of the participants must be incapable of sustaining a reliable transduction between perception and testimony. Both parties may feel quite righteous about their own subjective experiences. There is now recognizable a third possibility, namely, that the two individuals or groups may be witnessing significantly different events; perhaps they are living in quite different worlds. Knowing these facts obliges our recognition that some of the presumed skullduggery of the world may be assignable to such biological processes.

Escape from prior perceptual and other cognitive commitments can occur only under certain conditions. Basically, this requires exposure to and recognition of events that do not correspond to one's necessarily limited past experiences. Besides the experiencing of novelty, there must be added a strong motivation that seeks to achieve successful behaviour in face of the non-corresponding circumstances; exercise of an ability to relax from previous commitments sufficiently to create new models of the event whereby perceptions, judgements and actions can be more appropriately fitted to the occasion; and finally discipline enough to test out the new insights until they are adequately workable. The achievement is never final. This is basic to all forms of learning, for all sensory and motor as well as cognitive skills. It requires a creative act that is referred to as reorientation from prior commitment.

A much more drastic and far-reaching manner of surpassing prior commitments is that of reorganization. Reorganization involves the internal creation of entirely different perspectives. The general strategy for relating to the event, person or organization must be fundamentally shifted or reorganized. Thus, individuals may take an entirely different attitude toward themselves after an especially illuminating personal experience. Falling in love may be similarly revolutionary in the way it alters one's entire relationship to another individual. Climatic educational experiences, professional commitments and religious conversions can all be examples of radical and enduring individual reorganization. Institutions, ethnic groups, nations and groups of nations can similarly become reorganized, with their viewpoints, values, and activities drastically reordered. This is a relatively rare and consuming, highly creative process for the individual or the group.

Creativity demands certain definite criteria from the individual and from the environment in which he works. It cannot occur without subject mastery, strong motivation, a relaxed and nimbly imaginative play of ideas, and the discipline and talent necessary to test the newly created outlook and to communicate it to others. Creativity on a small scale is involved in every occasion of learning. Creativity can be fostered by specific educational design as well as by example. It needs aim and ambience. Acquiring creativity is so delicate a process that it is easily quashed. Creative contributions are indispensable for any form of educational and social progress. Like creativity, constructive adaptation can be taught and cultivated widely throughout society.

Conditioning (here taken to include all forms of learning) is of two kinds: conditioning introduced via sensory systems (Pavlovian or classical conditioning) and conditioning built around motor systems (Konorskian or operant conditioning). In the first, a conditioned stimulus is associated temporally with the unconditioned stimulus, as a bell followed by food for a hungry subject. In the second, the subject emits a motor act which is then 'rewarded'. Pavlovian conditioning demands more finesse on the part of 'teacher'. Konorskian conditioning is more under the control of the 'learner'. A somewhat more direct channel is opened for the shaping of behaviour in desired directions. Either form of conditioning can be used to form any behaviour that is within the potential repertoire of an individual or group.

Indispensable to learning of all kinds is reinforcement. Casually speaking, reinforcement involves the occurrence or administration of 'reward' or 'punishment'. Either form of reinforcement can be used to shape any behaviour that is within the potential repertoire of an individual or group. The effectiveness of reinforcements depends entirely upon the internal state of the subject. This is a good reason why subject initiative in learning experiences is so valuable, whether it is spontaneous or elicited. Central nervous mechanisms relating to positive reinforcements (rewards) are distributed throughout the entirety of the limbic system and most of the hypothalamus, with a rich panoply of different positively reinforcing mechanisms represented in different regions of that phylogenetically old system. Positive reinforcements lead directly to visceral satisfactions, to approach behaviours, strengthen external relations and yield exploratory behaviour. They not only provide immediate stimulus and control for educational purposes but strengthen the confidence, habits, and social bonds relating to future learning processes.

Central representation of negative reinforcements ('punishments') lies in the intermediolateral midbrain, some of the diffusely projecting thalamic nuclei and the posterior part of the hypothalamus. Activation of this relatively small group of contiguous tissues can serve to reinforce any form of learning but it leads to withdrawal behaviour, internal visceral turmoil, erosion of external relationships, and behavioural resorting to evasion and retaliation. Deterrence, a form of shaping behaviour by threat of punishment, is notoriously undependable in terms of shaping behaviour in desired directions. It has the characteristics of negative reinforcement, and, in addition, deterrence necessarily shifts the initiative into the hands of the individual or group that is presumably being deterred. Negative reinforcements, on top of their other disadvantages, depend strictly on the adequacy of the specific hormone (ACTH) put out by the anterior hypophysis under control of the hypothalamus. A small fraction of this chemical agent must act back upon the brain, upon specific nuclei within the diffusely projecting thalamic system (e.g. the parafascicularis). Any defect in this sequence leads to failure of retention of conditioned avoidance. This is manifested by failure to anticipate previously experienced punishments. It is suspiciously likely that individuals who are refractory to learning from punishment may be suffering from a defect in these mechanisms, possibly from the system being exhausted or perhaps simply turned off.

During learning, the following steps take place within the brain:

1. When a novel event is encountered and perceived as novel, strong arousal and orienting reactions take place under the control of limbic mechanisms for orienting and cephalic brain stem mechanisms for arousal.
2. When initial exploratory trials are found to be successful (i.e. achieve some form of reinforcement), activities have been detected circulating from limbic subcortical to limbic cortical stations.
3. As correct performances (and perceptions) become familiar, activities originating in limbic cortex are seen circulating into limbic subcortical stations and hence to hypothalamic

and midbrain reticular formation.

4. From the limbic frontal midbrain area some form of generalized 'now print' or 'now store' order is presumably to be distributed throughout the forebrain, perhaps by way of the diffusely projecting midbrain and thalamic pathways or perhaps by way of some chemically diffused signal.
5. The end result is that all recently active brain circuits become strengthened in their connexions—whether they are sensory, motor, visceral or systems for evaluation or whatever. The newly strengthened connexions thereupon increase the likelihood that these circuits will be available again, for perception, judgement and behaviour.

Education invariably takes place in particular physical environments and in particular philosophical and historical contexts. Uri Bronfenbrenner has depicted some of the differences that are wrought in perceptions, judgements and behaviours by two different cultural practices of infant rearing: education and generational expectations. The two systems he studied, those of the United States of America and the U.S.S.R., are by no means as remote from one another as are many other cultures throughout the world. In general, educational systems are calculatedly designed to reinforce traditional viewpoints and to instil a sense of distaste and distrust for alternative viewpoints. This has been biologically useful in the past because of man's need to learn to cope with a given peculiar environment. Now, because of man's technical capabilities, this may be countercontributory to man's evolutionary success. It appears that educational systems need to preserve and to honour cultural differences. But at the same time they must provide insight into the arbitrariness and idiosyncrasy of any given cultural habits. They must orient mankind to the maturing satisfactions that can be derived from being able to recognize and to exercise at least some different forms of perception, judgement and behaviour. On a trivial scale this can be likened to children learning different mathematical solutions to the same problem. An emergent capacity for cross-cultural appreciation appears to be indispensable to man's survival.

Man's brain is the instrument for both commitment and for reorientation and reorganization. His capacity for both talents has been the main factor in his successful evolution to date. Both need to be cultivated by educational programmes on a world scale and with a world viewpoint. This is urgently needed to ensure man's general cultural maturation and to safeguard his opportunities to advance to a new level of evolution.

Neurosciences techniques need to be provided better to serve education beginning earlier in life and throughout life. The goals of education need to be deliberately oriented toward liberating mankind from the biological and cultural provincialisms that have dominated man's past history and which now threaten his extinction. This will contribute not only to survival but it will contribute enormously to the quality of life and social well-being. We must try. We must succeed. We do not need crisis conditions before beginning; crises could only interfere with the opportunities we have for success. If we try but fail, we shall not have lost anything not already lost. Ours may be recognized as an age for constructive adaptations—we must use our brains for all they are worth. They are all we have to take the next steps for man.

Imagery as Function of the Individual, Environment and Cosmic

JOE KHATENA
Mississippi State University

Like many attempts to study the human mind and its relatively intangible, unobservable and unverifiable functions, the study of mental imagery has given rise to a variety of theoretical formulations that have invited differences of opinion yet to be resolved. The stunning blow dealt to it by Watson and Behaviorism prevented the proper development and greater understanding of this field of inquiry, except for the valiant few who persisted to keep alive our curiosity. The "return of the ostracized" aptly describes the readmission of mental imagery as a legitimate subject of study in psychology (Holt, 1964). Its revival coincided with the major preoccupation in and growth of cognitive psychology, and found expression in the study of dreams, day-dreams and fantasies, attention, feelings and emotions, altered states of consciousness (Holt, 1972), and interest in the paranormal, metaphysical and transcendental (e.g. White and Krippner, 1977).

In a larger context, this resurgence can be related to humanistic psychology under which may be subsumed a broad humanism: that finds the individual of intrinsic value with potential for development and becoming; that recognizes measurable individual differences and the prizing of their worth; that sees intelligence as multi-dimensional where the emphasis is less on a mechanistic concept of cognition and memory and more on a holistic concept inclusive of transformations, implications, and a creative consciousness; that creativity is not only seen as intellectual abilities but as psychological openness, mental health directional of self-actualization, and disposition to transpersonal and transliminal experiences; that perceives development of intellect and creativity of individuals as both continuous and discontinuous thus allowing for the peaking of linear type growth to shift to higher stages or levels of development, and development as integrated growth functions of psychomotor, affective, and cognitive processes; that gives parapsychological phenomena the credence of scientific investigation of the unknown; that recognizes the power of man's mind as revealed by, for instance, creativity, biofeedback, self-actualization, peak experiences and dream analysis; and that believes all phenomena to be natural and accounted for even though we may not be in possession of all knowledge (Gowan, 1978).

The significance of imagery as important to scientific inquiry has been established beyond doubt (Sheikh, 1977) such that questions about images now should pertain to the significance of their properties and representations, not their existence (Ashen, 1981). Considerable research and thought on the subject of imagery over the past two decades or so have led to a number of theoretical formulations. Among them are, for instance, the propositional model (Pylyshn, 1973) that rejects the image as a mere picture metaphor in favor of the image as a representation-plus-process; the dual-code model (Paivio, 1976) that attempts to connect visual and verbal representations into a theoretical unit logically assumed to be functional with memory; the analogue or representation model (Shephard, 1975) that asserts conscious images have a functional role in cognition; the role-playing model that assigns the role-playing function to imaging such that the image appears to be present in the act of imaging (Sarbin, 1972), or appears to be in an expectant state for receipt of appropriate perceptual information (Neisser, 1976); the cyclic model (Hampson and Morris, 1979) that is a combination of aspects of the proposition, analogue and role-playing constructs with the implication that images are produced and used by the same system; the cathode-ray tube model (Kosslyn, 1981) that likens its computer-generated displays to images as surface representations.

The historical account of imagery in American psychology by Hilgard (1981) and the ensuing thoughtful commentaries of it, notwithstanding personal bias, presents, by and large, current views on imagery. It is refreshing to find Holt (1981) reiterating the importance of philosophical issues to the study of imagery, the position of recognizing emergent properties of organism processes which have a reality of their own, and the need for investigating imagery problems, despite lack of complete objectivity, with the best measuring tools available, taking into account the error factor. Ashen's (1981) provocative interpretation of imagery as transcending beyond the reductionist, altogether logical, computer-analogic, and memory-informational based approaches to the more global universe of imagery ties imagery to Man's consciousness where an image is the illumination to his problem-solving activity, symbolized by the information-seeking syndrome of Sophocles' Oedipus Rex and the discovery syndrome of Homer's Odysseus. Image psychology, traditionally tied to the inhibiting aspects of memory, must free itself from memory if it is to grow viable and bear new fruit: an image is a psychical act that must not be confined to retrieving and interpreting but must be involved in transforming what it comes into contact with; consequently it must go beyond the operation of memory (Ashen, 1981b; Bugelski, 1970; Holt, 1972).

IMAGERY AND GENERAL SYSTEMS

A recent productive attempt (Kaufmann, 1980) sees imagery and language as operating within a problem-solving frame of reference that by definition goes beyond to operation of memory. Kaufmann's observation of current imagery research as concerning itself with memory and learning, while almost totally neglecting the possible function of imagery in more complex problem-solving activities, is to the point. In general, Kaufmann views language as an important symbolic tool of thought, in need of the assistance of visual imagery and overt exploratory activity as task familiarity decreases and demand for generating novel information increases. But while Kaufmann's position is evidently a genuine shift away from the mainstream approaches to more complex mental activity associated with the image, he does not go far enough. The move that must be taken should clearly show a shift of emphasis from information (phenomena) and process as monistic (in the idealism and material sense) or dualistic (in the metaphysical or epiphenomenalistic sense) to information (phenomena) and process as different aspects of a total reality (Holt, 1972) as well as interactive, especially as these relate to the factor analytic-based structure of intellect model where hereditary-based mental abilities operate with content organized in different ways.

Guilford (1972) suggests that an operational-informational psychology functioning such as the structure of intellect offers a much greater range of useful principles that provides a grammar for all thinking. Further, the structure of intellect can be reorganized as a generic problem-solving model synthesizing much that has been said about the storage and retrieval aspects of memory as well as the remaining four thinking operations of cognition, convergent production, divergent production and evaluation, as they perform specific problem-solving tasks. The incubation-illumination process which is an essential facet of creative problem-solving is closely related to imagery (Khatena, 1982) and must be involved in this shift of emphasis. To view imagery in the larger perspective of creativity is to go beyond the individual and his intellect to include what has been called the "creativogenic society" (Arieti, 1976) specifically, and the greater environment more generally. A third dimension may be added to those of the individual and the environment, namely, the cosmos. Here we are getting into general systems and its relationship to imagery, a provocative subject, highly speculative, but nevertheless fruitful as a source of generating hypotheses.

A number of recent scholars have, as some before them, strived to find explanation for the way things are in the universe, to discover the design of life, to explore the relationship of order and disorder. Tillyard (1956), while writing about Shakespeare's history plays, saw the need to understand the world as seen from the Elizabethan eye, and sketched the system of thought and belief that governed their behavior, which he called the Elizabethan World Picture (Tillyard, 1958). We learn from this system that order which prevails in heaven is duplicated on earth—the king corresponds to the sun, so that disorder in the heavens breeds disorder on earth; that everything was connected in a chain-of-being from the lowest forms of life through

Man to the highest archangels, with *degree* as a key concept—what Tillyard calls the vertical dimension of the world picture. This world picture was also organized horizontally to consist of a number of planes arranged one below another in order of dignity but connected by an immense net of correspondences. The different planes were: the divine and angelic, the universe or macrocosm, the commonwealth or body politic, Man or microcosm, and the lower creation. What took place in one plane affected other planes. The notion derived from the early Greek philosophers that creation was an act of music and that the created universe was itself in a state of music, or one perpetual dance, implying degree in motion, appealed to the poetically and mystically minded, and had its place in this system of thought as well. This one kind of general system evolved from religion, philosophy, politics, and generally from the way of life of a people; other general systems similarly derived are epistemology, ethology, cybernetics, and so on.

Recently, the search for models and plans has been intensified, and attempts have been made to discover constructs that would allow for conceptions of greater order and generalizability. Seeing principles in patterns for the derivation of even higher levels of order has attracted no small attention and has given rise to some extremely valuable contributions to thought. Theoretical speculation rooted in and deriving insights from, such disciplines as biology, physics, chemistry, mathematics, and psychology has produced a way of thought that has been called General Systems. Langham (1974), originator of the Genesa model, prefaced his version of General Systems with the following questions:

> If you had a magic key that would fit all makes of truth, would you use it? If it revealed principles and made them available to you, would you use them? If it unveiled answers to your problems, would you be happy? [p. 117].

In the past few years drawing from the advances in scientific and mathematical thought, Stuart Dodd, Derald Langham, George Land, John Gowan and several others have each attempted to find general principles to explain existence and behavior. Interacting with one another by mail, visits, and meetings such as the 1974 and 1975 ones held at the Creative Problem-Solving Institutes in Buffalo, New York, they attempted not only to convince one another of the significance of their systems but also to attempt to find a system of systems. As Gowan and Dodd observe (1977), "because General Systems theory is about generalities and not specifics, it is difficult to explain". However, George Land tells us that the "idea of General Systems is not complication but just the opposite—simplification, i.e., to discover the fundamental laws of Nature that apply in theory and practice to everything". As this relates to his "transformation model", *Grow or Die*, Land explains his general system in the following way:

> A general system starts with a very high degree of polarity—that is, on the one hand great disorder, and on the other hand, great order.
>
> At this initial stage connections are made between order and disorder by dominance and absorption-control. Initial order grows at the expense of the disorder. If successful, a pattern of order—an identity—is discovered and the system passes into its second stage, that is, the pattern is copied with few changes and either produces or connects to likeness. The relationships in this stage, rather than those of control or being controlled, now change to those of influence and being influenced. Rapid growth is possible since there is a pattern to follow. Inevitably the second stage of growth will use up its environment, i.e., run out of materials that fit easily into the initial and modified patterns. When this happens, the third stage of growth is reached in which the growing thing is forced to accommodate differences in the environment to continue growing. It is at this point that it becomes very sensitive and responsive to its environment and its relationships shift from the influence type to those of mutual sharing, simply because that is what works.
>
> Once a system has absorbed all the differences it can within its environment, and because they are shared, the differences become a new sameness and the organism finds a new identity. It must begin to relate to a new and broader environment—a new disorder—and the process

> starts all over again at a higher level. [Land and Kenneally, 1977, pp. 19-20]

An earlier discussion (Khatena, 1979a) proposed that imagery, especially as it relates to creative imagination, incubation, and right-brain activity be considered as a sub-system of general systems, finding explanation for this in 'periodicity' (Gowan, 1974) and 'transformation' (Land, 1972) as prefacing entry from a lower level to the next higher level of 'development' or 'growth' respectively (p. 700).

The highest level of creative process that prepares for periodicity or transformation in both Gowan's and Land's systems, involves the functioning of analogical and metaphorical brain activity, and the tapping of the preconscious—functioning of the right brain, the creative imagination and its imagery correlates (p. 708). All these activities are of the individual and indicate one dimensional source of imagery. However, if we are to take the testimonies of, for example, the literary, musical and scientific giants (e.g., Samuel T. Coleridge, Johannes Brahms, and Albert Einstein) about their creativity, we must admit of an outside non-physical/supranatural or cosmic force that influences at the critical moment: composition. This may be considered a second dimensional source of imagery—difficult to verify or even to study, yet significant to the emergence of illuminating experiences that have led to important solutions in many a great work of art and science. Further, there is the view that a person's creativity is dependent upon nurturant socio-cultural influences or what the late Arieti (1976) has called the "creativogenic society", and the events and impact of the environment in the widest sense. These outside-the-individual factors, and the physical universe, the reality external to the individual and his contact with the real world make up the third dimensional source of imagery. This suggests a three-dimensional system consisting of (1) the individual, (2) the environment, and (3) the cosmic, in interactive association and as the source of imagery involved in creative activity.

Individual-Environment-Cosmic Imagery System

Let us take a closer look at each dimension of the dimensions of the Individual-Environment-Cosmic Imagery System (IECIS) in turn:

1. *Individual*

This dimension concerns everything that constitutes the individual, namely, the physiological and the psychological, whose center is the individual. Structures and functions of both facets of the one human reality are at one and the same time complementary and interactive. Relevant to the intent of this paper is the focus on the psychological generally and the intellect specifically; physiological will find inclusion in so far as the senses receive and transmit information from the external world to brain centers activating intellectual functions for output and communication. The theoretical model that best allows for explanations of this position is the structure of intellect (Guilford, 1967), whose geometry accounts not only for the hereditary-based mental operations (cognition, memory, convergent thinking, divergent thinking, and evaluation) but also for their action upon and interaction with several kinds of content (figural, symbolic semantic and behavioral) that can each come or be organized in several different ways as products (units, classes, relations, systems, transformation, and implications). As the structure of intellect relates to imagery, several pertinent observations can be made:

(a) Relative to the content dimension, the figural pertains to nonverbal information, obtained via any one or another of the sense modalities (the visual and the auditory receiving major emphasis) transmitted to the brain as images from a primary source for intellectual processing; the symbolic and the semantic relate to the coding and the meaning of primary information in alphanumeric form, so that the appearance of imagery in the brain is activated by a secondary source and are consequently re-creations of the original experience; the behavioral deals with information that involves at least one other person, and may very well be in its primary nonverbal or language form, and the source of imagery in the verbal form, similarly secondary reactivated imagery of the original experience.

(b) Relative to the *product* dimension, organization of informational content, being an intellectual function, acts upon rather than is receptor to imagery, so that, for instance, several images of external objects (e.g., apple, orange, banana, pear) take on the properties of a class (fruit) as a result of intellectual organization.

(c) Relative to the *operations* dimension, received information may be processed by the five hereditary-based mental operations. That is, information received as images is then acted upon by mental operations in various ways such that knowing, understanding and comprehending (cognition) of the image is the mental operation prerequisite to storage and retrieval (memory). Coding of the image in verbal, numerical, musical and other symbolic forms may take place simultaneously or soon after the formation of images as a cognitive event, and may be organized and labelled, for instance, as classes, relations, and systems. Storage of this information as images and their language representations may follow when 'accommodation' and 'assimilation' may be said to occur for the new information to be accepted, for old patterns to be refined so that new patterns may emerge. It is my hypothesis that dual storage takes place so that both images based on primary sources and their language representatives are put away for use at a later time. There is a view that storage of images is expected to take place in the right brain and their language correlates in the left brain while recognizing the integrated functions of the two hemispheres. Although we may recall images with their language labels, it is more frequent that language representatives are recalled, especially in preparation for spoken or written verbal communication. Retrieval of images for communication in language systems that are predominantly pictorial (e.g. Kuo-Yü—the written form of Mandarin), or in art forms of paintings (e.g. the earliest expressions of art in caves made by artists who relied on their own remembered images, since the animals they portrayed were not in the caves), or dance (e.g. the live art forms of native African dancers, the ballet, or the art of gesture and mime) is more direct whereas retrieval of language representations of images for the purpose of communication in oral or written form is indirect and may require considerably more effort on the part of the recipient to enter into image experiences that the language form attempts to communicate.

The mental operations of convergent and divergent production act upon the information as images received, retrieved or the two combined, such that convergent thinking concerns itself with the procession of images that lead to a single right answer, whereas divergent thinking concerns itself with the processing of several alternative answers. These two mental operations often call to play yet another operation—evaluation, which concerns itself with judging the appropriateness, fitness, effectiveness, and so on, of the possible answer or answers against the criteria so that a final or best conclusion may be reached. Whether or not these mental operations handle images (or their language correlates), the key factor here is processing.

All five mental operations are involved in the structure of intellect problem-solving process. Guilford's generic problem-solving model illustrates the respective roles of these mental operations from entry to exit of information. He considers that this problem-solving model is the best place to view the working of the components of intellect (Guilford, 1977). When a problem is encountered, it becomes necessary to go beyond the items of information that have already been structured: a need then arises for new intellectual activity that goes beyond comprehension or understanding to include productive thinking. His model is a communication system, or informational processing model, showing the events of a problem-solving episode spread over time, from start to finish, with input from the environment and input from the soma which includes feeling and motivational states. While all five mental operations are involved. Guilford considers that memory storage to cognition and production operations may at times pass through the filtering function of evaluation, but at other times it may be transmitted directly to the mental operations for processing, as in the case of suspended judgement. Evaluation is ongoing at every step of the problem-solving process. An important feature is looping, involving feedback information that allows some flexibility with respect to the order of events, for instance, the need for backtracking to earlier stages of the problem-solving process or even going back to the environment for additional fact finding when we discover that our failure to solve a problem is due to wrong cognizance of the problem. Restructuring of the problem and a new round of problem-solving operations that follows calls our attention to the fact that more than two cycles of problem-solving activity may be involved before the goal is attained. These and other details may be found illustrated in the *Nature of Human Intelligence* (Guilford, 1967, p. 315).

The structure of intellect problem-solving model acts upon the four kinds of information described, and in so far as this information is figural, it concerns images; symbolic-semantic informational sources are to be considered as secondary or representations of images; the behavioral, as was pointed out, are events or experiences involving at least one other person and may also be considered as a primary image source prior to their coding in some language form. Essential to creative aspects of the problem-solving process is the activity called incubation, the process of metamorphosis that produces creativity via right-hemisphere imagery (Gowan, 1981).

Another dimension of the individual's mental functioning relates to several levels of awareness. Freud had divided the mental life of a person's psyche into the conscious, the preconscious, and the unconscious, explained simply by Sullivan (1953) as the 'good-me', 'not-me' and 'bad-me'. Good-me is that part of an individual's mental life of which we are aware and which can be called the conscious positive self-concept; its optimal functioning state shows intellectual operations in full command of informational input to the brain from both external and internal sources. Not-me or the preconscious is that part of mental life where frightening and uncanny experiences occur much like those encountered in dreams and nightmares: it is an area of mental life of which we are not fully aware, though accessible. and the source of our creativity. Bad-me or the unconscious refers to that part of mental life where images, ideas and drives that cause too much pain, anxiety, or guilt are stored beyond our conscious awareness, or repressed to defend the self or ego where they remain active and are cause of some of our behaviors, noticeable when defenses are relaxed as in dreams, or in slips of the tongue, or when under the influence of alcohol. The intuitive use of the preconscious by creative individuals manifests itself in works of art of one kind or another; however, at high levels of creativity (psychedelia, or state-of-mind expansion without the help of drugs) barriers separating the unconscious and the conscious may be thought of as doors that swing open to let in, as it were, the resources of the preconscious for cognitive processing and production (Gowan, 1974).

Arieti (1976) would relegate endoceptual activity to the preconscious. He describes the 'endocept' as an amorphous cognition that occurs without representation (i.e., expressed in images, words, thoughts, or actions of any kind); an internal private occurrence, a nonverbal, unconscious, or preconscious cognition; a primitive organization of past experiences, perceptions, memory traces, and images of things and movements; something felt as an atmosphere or intention; a 'global' experience that cannot be divided into parts or words and very similar to what Freud called 'oceanic feeling' (pp. 54-55). Further, Arieti points out that although endocepts may remain endocepts they tend to undergo various transformations into communicable symbols (e.g. words, drawing, number, and sounds), actions, more definite feelings, images, dreams, fantasies, day-dreams, reveries, and so on, possibly constituting the spring-board to creativity (p. 60), has the character of intuition and inspiration (p. 61) and is activity in part during the incubation stage (p. 65).

A third aspect of the individual dimension relates to intellectual and creative development both as changes in terms of chronology relative to continuous or discontinuous growth, and transformative leaps relative to stage and systems theories, such that the former derives its meaning from measurement of abilities with increasing age or from developmental stage theory, and the latter from general systems models that refer to growth or developmental stages (Khatena, 1982).

Development as continuous has its conceptual framework in the measurement correlates of hereditary-based ability(ies) and its interactive environmental properties distinguished by the Danish geneticist Johannsen as genotype and phenotype intelligence (Hunt, 1964), or as Intelligence A and Intelligence

B (Hebb, 1949), and which is inherent in the structure of intellect model (Guilford, 1967). The works of Guilford (e.g. 1967) and Torrance (e.g. 1962) have required the inclusion of the measurement correlates of divergent thinking and creativity as essential components of the construct. Consequently, when the development of intellect and creativity as continuous variables relative to age are considered, it must be remembered that it is the psychometric properties in terms of scores of tests that provide the evidence for any judgement about developmental patterns.

Wechsler (1950) has suggested that for some mental abilities growth is discontinuous, as instanced by the age curve for memory span of digits which, unlike other growth curves (e.g. vocabulary and information), comprises a series of risers connected by varying breadths. This may very well be due to instruments whose units of measurement are insufficiently discrete to show gradual change in scores characteristic of a continuous variable; or it may be due to the discontinuous functions of certain amounts or quanta much in keeping with thoughts about growth in terms of developmental stages.

Shakespeare's seven ages of Man, Freud's five developmental periods of sexual libido, Piaget's cognitive, Erikson's affective, and Kohlberg's moralistic developmental stages, to mention but a few, state (each with different emphasis) that qualitatively different developmental stages exist. All this points to the high relevance of the developmental stage theory. To cite Bailey (1971), these men and others like Maslow, Bruner and Bloom, "seem to be united in their belief that the maximization of the human potential within the constraints of each life stage is the best way of preparing for succeeding stages" (p. 14).

Gowan (1972, 1974) combines Piaget's cognitive and Erikson's affective stages with his own on creativity, psychedelia, and illumination (an extension of Piaget's five, to eight stages), and presents them as the Erikson-Piaget-Gowan Periodic table of Developmental Stages in a 3×3 matrix (p. 51). Two recent studies (Arlin, 1975; Weinstein and Altschuler, n.d.) corroborate the earlier views, for instance, of Piaget (cognitive stages), Erikson (affective stages), and Havighurst (adolescent developmental tasks). Arlin (1975) predicts as developmental cognitive stage following Piaget's formal operations stage calling it problem-solving (Gowan's creativity stage) which Epstein (1977) considers as prediction of a hitherto unknown stage. That Piaget did not formulate this and other stages beyond formal operations can perhaps be attributed to the unwillingness of Piaget's children to continue to submit themselves to the daily drudgery of observation (Gowan, 1979). Koplowitz (1978) recently proposed that two higher stages beyond the usual Piagetian cognitive ones exist, namely, a *systems* stage where the individual understands complementarity, homeostasis and interdependence (resembling Gowan's creativity or the sixth stage), and a *unitary operational thought* stage where the individual understands that the manner in which the universe is perceived is only one of several possible constructs (resembles Gowan's psychedelic or the seventh stage). This is consistent with the current view expressed by others that there may exist higher cognitive stages beyond Piaget's formal operations stage (e.g. Arlin, 1975; Epstein, 1977; Gruber, 1973; Vygotsky, 1974).

Development as transformation leaps relates to the developmental stage theory (Gowan, 1972, 1974), which can be regarded as the carrying over of the discontinuity principle of the quantum theory to behavioral science. Escalation is the jump from one riser to the next on the developmental staircase; energy from the organism is required for such jumps, but certain freedoms are gained thereby. If we ask, "What is escalating?" one answer appears to be ego strength which helps control and develop the creative imagination, as may be seen in comparison between the horrors and dread of night terrors in the child, and the beauty and simplicity of a musical or mathematical product in the adult. Developmental process centers around stabilizing and controlling the creative imagination, and harnessing it to constructive and destructive use, an activity related to the preconscious (Khatena, 1981).

Coming from an entirely different perspective is Land's transformation theory which has already received some attention earlier in this paper (p. 136). The key concept of Land's theoretical model is *growth* which he defines as "the process by which things become connected with each other and operate at higher levels of organization and complexity (Land and Kenneally, 1977, p. 19). Fundamental to his model is its high degree of polarity: that is to say, things move from states of disorder to states of order, and from these states of order they move again to disorder prior to attaining higher states of order. He explains that things, organisms, and events move in triadic sequential stages which he calls *accretive*, *replicative*, and *mutalistic*. The triadic growth stages, if they are to repeat themselves at the next higher level of growth, must be prepared at the mutalistic stage for disorder to occur so that a transformation to a new and higher order may emerge.

Gowan, like Land, perceives 'growth' as essential to developmental stage theory calling it development. Making a distinction between the two he says that development is to growth what quality is to quantity, such that the apple enlarges but it also ripens. However, it may be an error to restrict the meaning of "growth" as used by Land to this interpretation since qualitatively different levels are achieved each time a leap occurs from one stage to the next and, for transformation, nothing short of a quantum leap precipitates its emergence.

Gowan's system pivots on the development of the creative individual and so concerns itself with those stages of development optimal to creative interactions of the inner and the outer worlds of the individual, Land's third or mutalistic stage in his general systems interpretation of the creative process. *Transformation* in Land's model is little different from Gowan's *periodicity*: both preface the entry into the next higher level of "growth" or "development". In both models, the highest level of the creative process that prepares for transformation involves the functioning of analogical and metaphorical brain activity, and the tapping of the preconscious, what some at present would refer to now as the right-brain functioning, or the functioning of the creative imagination and its imagery correlates. It is at the mutalistic or creativity-psychedelic stages (the higher levels of psychological functioning) that imagination imagery occurs; here high level combinations and connections are made by analogy and metaphor and at which time the preconscious is tapped. When movement taking place from a lower level of order moves to a higher level of order via the process of destructuring and reintegration, transformation occurs (Khatena, 1982).

2. *Environment*

This dimension refers to everything external to the individual: the physical universe, other persons both as single individuals and as constituents of socio-cultural groups, and events that together make for the individual external reality which is internalized to become the inner and private reality of self and the controls of the individual's mental life and experience. By its nature this dimension is developmental, that is, its shaping influences are spread over time, and its effects are gradual for the most part, although its effects may be contemporaneous if not immediate. Of particular interest here is the development of intellect and creativity which cannot be treated as isolated from its socio-cultural origins. Both Simonton (1978) and Arieti (1976) have asked the crucial question why creative geniuses appear at one time and place and not at another, attributing such occurrences that appear in clusters to certain socio-cultural events that significantly affect the creative development of individuals.

Simonton's (1978) historical survey of the conditions responsible for the emergence of eminent men like Shakespeare, Michelangelo, Bethoven and Aristotle makes a critical distinction between two phases of a creator's productivity period (e.g. warfare and its aversive impact or output at a certain career point); and events during the creator's developmental period. Of the two, Simonton considers the latter as more important to the emergence of eminence: the developmental periods of the child growing up through adolescence to adulthood appear to be more significantly affected than the period during which time productivity is manifesting itself. Seven major factors are identified as having influence on the creative developmental periods of geniuses, namely (1) formal education (important positive influence but inhibitive to creative development if it is of the wrong kind); (2) role models of eminent creators for emulation (best if models are in the same discipline but, if too many, may lead to premature commitment to a school of thought that makes of the genius a discipline rather than a leader); (3) the zeitgeist (leads geniuses to become preoccupied with elaborating ideas to which they were exposed, and to act as synthesizers who make prior accomplishments a single unified philosophical system); (4) political fragmentation or the existence of many independent states within a civilization engendering cultural diversity (helps in the shaping of the creator's intellectual base towards an openness to experience, change, individualism and material welfare); (5) constant warfare (discourages those qualities shaped by political fragmentation); (6) civil disturbances like popular revolts, rebellion and revolution (potent influence, though at times they can have a negative impact; and (7) political instability (detrimental to creative development since the world becomes unpredictable or uncontrollable with little prospect for personal efforts to reach fruition).

Arieti (1976) directs attention to the positive aspects of socio-cultural conditions that influence the shaping of the individual's genius as he grows up and who in turn shapes the culture of which he is a member. In making a distinction between the infrequent and clusterlike occurrence of genius and individual possibility for genius, Arieti shifts some of the control of creative development to society and culture which by deliberate planning promote and activate creativity. Both the individual and the culture are perceived as open systems such that the genius gives to the culture and takes from it. Such a society he calls "creativogenic". Arieti suggests that the individual makes two contacts with culture, namely, when he makes use of his biological equipment to understand his environment and satisfy his needs, and when he acquires things already present in the culture mediated by interpersonal relationships. A creativogenic society makes available to an individual elements that the individual perceives or accepts as similar to his own characteristics. This prepares the way for a *magic synthesis* that produces innovation which in turn is offered to and becomes a part of culture. While a creativogenic society offers the individual the possibility of becoming great, it does not make the occurrence of greatness automatic.

Conditions present in a creativogenic society include the availability of cultural means (an elite, at least, must preserve these cultural means which extends as well to physical means such as access to scientific equipment or to materials such as marble, iron, wood, paint 'and so on' for artistic work); openness to cultural stimuli (cultural stimuli present, requested, desired, and made easily available); stress on becoming, not just being; freedom, or even retention of moderate discrimination, after severe oppression or absolute exclusion, is an incentive to creativity; exposure to different and even contrasting cultural stimuli; tolerance for and interest in diverging views; interaction of significant persons; and promotion of incentives and rewards.

Geniuses are recognized as having potential to become eminent via creativity by Simonton and Arieti: the former makes a distinction between the occurrence of creative productivity at a certain point in a person's life, and creativity as a part of development in the formative years of an individual facilitated or hindered by cultural conditions; the latter regards creativity as a dynamic exchange of two open systems—the individual and creativogenic society—where the emergence of eminence is facilitated by certain conditions. Whereas Simonton says that the developmental period is more important and best fostered by certain cultural conditions (with the exception of political instability), Arieti emphasizes the importance of matching creative characteristics of the genius and his culture and the conditions that best foster this relationship. It may be that a combination of both the views offer a better understanding of creative development as it is influenced by socio-cultural forces.

3. *Cosmic*

Of the three dimensions, the cosmic can be considered as inviting the most controversy; yet its relationship to the other dimensions, the individual and environment, cannot be ruled out or denied (even though objective verification may not at present appear feasible); in fact it has been considered by numerous thinkers of the world as essential to the unity of Man and the Universe. The cosmic may be thought of as the original creative life-force whose power and action are manifest in all that is, the grand source of all creativity, products of which are but specific instances of it. The parent of inspiration in the highest sense, the cosmic has been perceived by geniuses in the arts and sciences as necessary to the creation of their great works—awe-inspiring experiences when they are one with the Creator. The creative energy in Man is merely a projection in microcosm what is of the macrocosm, the force that sets in motion the magic and mystery of creative imagination to give articulation to the world, transforming reality to dreams and dreams to reality. Poets and artists in the classical tradition of Rome and Greece invoke the Muses to inspire great composition. The Romantic poets identified imagination with 'spiritual energy' (William Blake), 'absolute power' (William Wordsworth), 'ability of prime importance' because human beings in their creative activity simulate the creative act of God (Samuel T. Coleridge).

Imagination is differentiated by Coleridge as primary and secondary:

> The primary imagination I hold to be the living power and prime agent of all human perception, and as a repetition in the finite mind of the eternal act of creation in the infinite I AM. The secondary I consider as an echo of the former, co-existing with the conscious will, yet still as identical with the primary in the kind of its agency, and differing only in degree, and in the mode of its operation. It dissolves, diffuses, dissipates, in order to re-create; or where this process is rendered impossible, yet still, at all events, it struggles to idealize and to unify. It is essentially vital, even as all objects are essentially fixed and dead. [Coleridge, 1817/1956, p. 167.]

In the words of the nineteenth-century composers, inspiration is of divine origin. Brahms felt it as vibrations that thrilled his whole being; Puccini said of his composition of "Madame Butterfly" that the music of this opera was dictated to him by God; and Wagner felt himself to be one with this vibrating force. Vibrations felt in altered states of consciousness when high creativity occurs, suggests a resonance effect, as observable, for instance, in the sympathetic vibrations of an untensed snare of a drum to the bowing of a string on a bass. The composer experiencing 'vibrations' can be seen as "being in tune with the infinite" much like a "radio receiver when tuned to the exact wavelength of the sending station, can amplify and recover sound made miles away" (Gowan, 1980, p. 283).

The relation between the individual and the cosmos has again received much attention over the past decade or so resulting in many speculative discussions about man's relationship with the universe; the most provocative of which is the Pribram-Bohm hologram model of ultimate reality. A hologram is an interference pattern on a photographic plate: light from one of two laser beams, known as the reference beam, reaches the plate direct while light from a second laser beam is deflected by a mirror from an object to the plate to produce a hologram of the object. The model suggests that the brain is a hologram interpreting a holographic universe: it mathematically constructs 'hard' reality by interpreting frequencies from a dimension, transcending time and space. As any piece of a hologram reconstructs the entire image, so, to the brain, a bit of the greater hologram reconstructs the whole (Ferguson, 1978; Pribram, 1978). To David Bohm, the hologram is an example of the enfolded or implicate order as compared to what we normally see which is the explicate, or unfolded order of things, a kind of mother and father to this second-generation reality (Ferguson, 1978).

These three dimensions, the individual, the environment, and the cosmic in interactive relationship play significant parts in human functioning generally, and imagery specifically. As the Individual-Environment Cosmic Imagery System (IECIS) relates to the individual, one can see continua of abilities that range from very low to very high, of emotionality from low to high sensitivity, of states of consciousness from full awareness to complete unawareness, and so on. The environment dimension may also be perceived as spread along continua from the least to the most exposure and influence to it as these apply to the multiplicity of environmental variables. Although one would like to perceive cosmic influences in the same way as the other two dimensions (i.e., as ranging along continua), this does not seem to be the case: it may be more appropriate to regard cosmic influence in an all-or-nothing way—one is either illuminated or not.

Let us draw a single line to represent the individual dimension along a continuum from, say, -4 to $+4$ standard deviations through a mean of zero (X axis) and do likewise for the environment dimension (Y axis as the coordinate). The four quadrants then would represent the areas of interactive relations of these two dimensions such that:

Quadrant 1 represents an optimum situation where both the individual and the environment dimensions are in positive interaction.
Quadrant 2 represents positive interactions of the environment dimension with the negative of the individual dimension.
Quadrant 3 represents negative interactions of both dimensions.
Quadrant 4 represents negative interaction of the environment dimension with the positive of the individual dimension.

Of the four areas of interactions, it is Quadrant 1 that has the greatest potential to receive cosmic influences, especially focused on the area of interactions marked off by the two +3 standard deviation coordinates above the mean as indicated in the shaded area of Figure 1.

Persons who occupy positions in the shaded area of Quadrant 1 are those who not only possess an intellect in the upper regions of genius, but also possess uniquely striking power to make contact with an impersonal universal source of knowledge identified as the 'collective consciousness'; such persons possess what Gowan (1980) calls 'exotic abilities'. Gowan defines exotic abilities as extensions of more ordinary abilities, available yet held ephemerally and tenuously by the possessor, and not under the possessor's full control; these abilities are most dependent on careful tuning and attention to small vibrations, and have the power to amplify what comes to the mind; they are creative in the sense of being able to extend the incubation processes from an unconscious to an intuitional practice but whose mechanism of practice and production is never well understood by the possessor; they represent in wild form the nascent sport or mutant ability which practice and education domesticates in an enhanced power; they represent earnests of the fact that Man is created

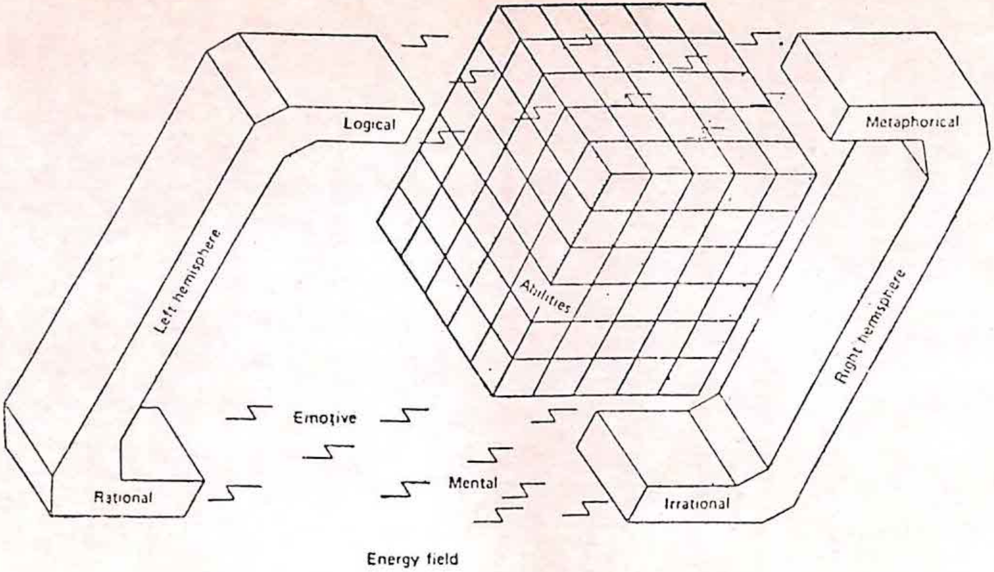

FIGURE 1. *Intellectual Abilities activated by Energy Fields*

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in the cosmic image which in its totality possesses *in posse* all the transcendent abilities of the Creator (p. 52).

Geniuses of this kind have been responsible for leaving behind a rich cultural heritage of ideas, thoughts and feelings that has manifested itself in their great contributions to art, music, literature, drama and poetry, philosophy, religion, science, politics, and so on. The efflorescence of the greats are not an everyday occurrence and some of the patterns highlighting the conditions for its occurrence have been discussed by Simonton (1978) and Arieti (1976). But they have made a difference to our lives and somehow, without full awareness, our minds are made up of their stuff, with the potentiality and capacity for germination and creativity.

PROBLEM-SOLVING, INCUBATION, AND HEMISPHERICITY

The way imagery research and theoretical formulations have progressed while expanding the field in one sense has set up limiting boundaries in another. Approaches to the study of imagery have favored, by and large, models analogically mechanistic and, in its most recent manifestation, the logic of the computer. These efforts have produced hosts of operational hypotheses that have given direction to the study of the physiological and mental processes involved to tease out the nature and function of the image and to a lesser extent their relationship to verbal processes. As this relates to mental operations, investigations have depended mainly on cognitive and memory functions which somehow have become interfused with the image to receive labels as eidetic image, memory image, or imagination image. A clear distinction needs to be made between the sense input data whose image correlate is but a representation of it, and the various processing operations that may be called to act upon the image. The mental operations of convergent, divergent, and evaluative thinking operations processing the image have not received the study they deserve. Almost any mental activity involving creative processing will bring into play these three mental operations as well: study of their use needs to be extended from language representations of images to the images themselves. Guilford's generic problem-solving model shows involvement of all those mental operations on information of various kinds organized in different ways and may very well be one of the best starting places for investigation. Memory as a mental operation of storing and retrieving is distinguishable from storage location, a problem that troubled Pribram in years of experimentation (whose results showed no specific location in the brain, rather a spread around of stored information) until he came up with the hologram as an exciting model that offered an explanation for storing image information in dispersed (rather than localized) fashion throughout the brain. To Guilford, memory forms the base of his problem-solving model: given a problem, all mental operations are activated and directed to find solution; although input from sources external to the brain is an ongoing activity, these mental operations are highly dependent both on access and use of memory storage and on incorporating and utilizing freshly obtained information, the model constantly allowing for this.

This generic model incorporates the several sequential-step approaches to creative problem-solving offered, for instance, by John Dewy, Joseph Rossman, Graham Wallas, and James Vargiu (Khatena, 1982). Both Wallas and Vargiu's problem-solving steps include incubation-illumination. Incubation is an important activity of the brain in the creative process, when mental events, earlier set in motion by deliberate intensive preparation are energized to become autonomous for the occurrence of fruitful insights leading to good solutions to problems. Gowan (1978) has described incubation as "the mental analogy of physical gestation in which an ovum is developed into a baby"; and as "the process of metamorphosis, and right-hemisphere imagery is the vehicle through which incubation produces creativity" (p. 30).

The main characteristics of incubation are: (1) intensive and careful preparation, (2) no conscious or voluntary thinking of the problem in hand, (3) optimal functioning through either relaxation or rest with no interference from conscious thought about the problem or when attention is given to solving other problems, through a series of incubations, and (4) facilitation of the right-hemisphere or creative imagination imagery for the occurrence of creative solutions (Khatena, 1982). We have the testimonies of men like Sumuel T. Coleridge, Henri

Poincarè, Friedrich Kekulè von Stradoniz, Albert Einstein, and Nikola Tesla (Ghiselin, 1955; Koestler, 1964), for instance, to support the occurrence of imagery during incubation that was precursor to illumination and solution-finding in their great discoveries or compositions. Empirical and experimental studies of the incubation-imagery-illumination process have not been many, and examples of these have been given elsewhere (Khatena, 1982a).

The problem-solving aspects of imagery is but one dimension of the creative imagination imagery calling for the use of the five Guilfordian mental operations. The structure of intellect model and its problem-solving model correlate do not overtly show involvement of the energizing activity of the emotional-motivational system for the occurrence of the creative imagination imagery, the interactive effect of which has been observed by Eccles (1958-1972) as "a peculiar potency for unresting activity, weaving the spatio-temporal patterns of its engrams in continually novel and interacting forms that sets the stage for the deliverance of a 'brain child' that is sired, as we say, by creative imagination" (p. 40).

Vargiu (1977), theorizing on the subject, suggests that the function of imagination may be thought of in terms of the activity of creative energy fields that are both mental and emotive. Drawing on the analogies from the world of physics, he tentatively defines the creative process as "a large number of simple 'mental elements' within the boundary of 'creative energy fields' which have such properties that (1) each mental element will respond to the influence of the creative field, and (2) all mental elements can interact with one another" (p. 23). To illustrate this, he describes the well-known behavior of a thin layer of iron filings in the presence of a magnet. By analogy, he suggests that mental events pass through the stages of preparation, frustration, incubation, illumination, and elaboration; and the suddenness of illumination he explains as 'avalanche effect'. Before illumination, there is the state of incubation. Vargiu suggests that this state is not a statistically random ordering of mental elements. Rather, it is the dynamism involved by the creative energy field that, in the initial part of the creative process, passes through the stages of preparation, confusion, and frustration that lay the groundwork for incubation and illumination.

Vargiu then expands this model to include the emotional field that runs intact with the mental elements, tending to organize these mental elements into configurations that correspond to their own energy patterns. It is this interaction between the mental elements and the emotional field that constitutes the very essence of imagination so that images are formed in the mind and energized by feelings.

The function of creative imagination involves intellectual abilities as well as energy fields that operate in various ways to lead to incubation, creative imagery, and illumination in the creative process. Drawing from the Guilfordian conception of intellectual abilities and Wallas's and Varigu's thoughts on creativity and problem-solving processes, it is possible to perceive abilities energized by magnetic field of forces—both mental and emotive—as central to creative functioning. Activity set in motion by imagination causes these forces to act and interact with each other and with intellectual abilities. This activity may be deliberate or ongoing without our full awareness; however, if a problem is presented for processing, incubation is induced and often produces the imagery that leads to illumination and problem-solution. This is illustrated in Figure 2 (Khatena, 1979b).

Editorial comments in *Educating the Ablest* (Gowan, Khatena, and Torrance, 1979), which introduce several papers on imagery, point to the importance of incubation in problem-solving as a sufficient condition for illumination and production of right-hemisphere imagery. Although a good repertoire of educational techniques of preparation for creativity are available, equally strong techniques for incubation are hard to find. Measures of verbal originality, *Thinking Creatively with Sounds and Words* (comprising *Sounds and Images* and *Onomatopoeia and Images* (Khatena and Torrance, 1973-1981) allow and encourage production of imagery and analogies. On the subject of analogies, Upton (1961) emphasizes the shift in the development of thinking from categorizations to analogy and finally to isomorphics, or a study of the equivalences in analogies. Thinking by analogy and imagery can be facilitated by various incubation techniques that sever the dominance of the left-cerebral hemisphere to allow right-cerebral hemisphere activity. Synergistic cooper-

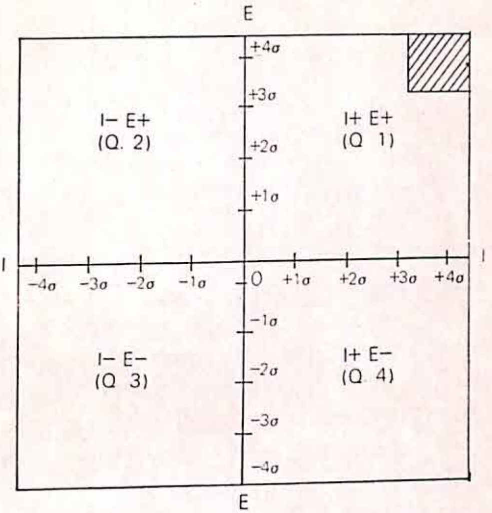

FIGURE 2. *Relationship of Individual-Environment Dimensions illumined by the Cosmic*

ation between the right and the left hemispheres permits the former to pick up the images and the latter to translate them into alphanumeric form (Gowan, 1979). The importance of incubation in the creative thinking process must not be underestimated although its study is elusive experimentally (Olton, 1979) and presents problems. It is difficult to control what subjects do during the period of incubation, other than their incubation activity, except for brief periods that last for minutes only (Guilford, 1979). Besides, subjects have the task of avoiding premature closure so that they may give due emphasis on the role of transformation. However, enough is known about incubation to justify attempts to teach problem-solvers to use it successfully (Guilford, 1979). Torrance (1979) suggests a three-stage instructional model for enhancing incubation, namely, an introductory phase that arouses anticipation and heightens expectations; a second phase that deepens involvement along with commitment that goes beyond the superficial; and a third phase that keeps the thought process active. To this end three books were produced: one that has a chapter on stimulating the use of the creative imagination imagery, conditions which parents and teachers can arrange for their creatively gifted (Khatena, 1978c), a second that does this with a section on incubation, activities that teachers can plan to encourage among gifted students (Khatena, 1979b), and a third that facilitates the incubation process in young people and adults (Khatena, 1981).

Images are the natural language of Man so that thinking first occurs with images as content; mental operations manipulate and use this content in various ways and for different purposes. Education concerns itself with teaching us early in our lives to use language which is a symbolic form of images: this means that instead of utilizing the natural image content, we use its symbolic referent for ease in communication via language. However, while the language of words tends to linearity, the language of imagery is multi-dimensional: the one has the links of logic, sequence, and step-wiseness, the other has volume and density for metamorphosis.

Once formed, images may assume a life of their own, or have autonomy, but through processes of assimilation and accommodation, synthesis-destructuring-restructuring, and analogy, images may be put to work for transformation and productivity. Interacting with the mental-emotive life or psyche of an individual, images may assume symbolic value and become recorded as representations of the individual's life patterns, character, style of thinking, and so on. Images so recorded interact with the individual psyche or with the recordings in the mental life of an individual not totally his or her own but rooted in the culture and civilization of which the person is a part, and the cosmic. The resultant of the interaction is a body of image patterns that are peculiarly individual, and common to all mankind at one and the same time. Herein lies the origins of imagery which takes symbolic and metaphorical shape, becoming a significant source and telling force of the pattern or schema of Man's thoughts and nature by which we can begin to know him and understand those fundamental springs of behavior or action, whose manifestation has better than chance value.

Man has invented a language system that allows for speedy communication, and images, like raw data fed into a computer, become coded in his brain in a symbolic system that simplifies storage, facilitates use, and provides a meaningful response when signalled to do so. High-speed processing of information by the machine is effected by programmed instruction; the brain is also programmed to perform certain operations to process information, but, unlike the static machine, is a dynamic open system that has a built-in programmer, as it were, to instruct the performance of the operations or to modify the instructions even while processing is occurring as changing physical and mental events warrant.

Recordings of both images and their language correlates are made and stored (with or without our awareness) in the brain. In the act of creative use of these experiences or events, some persons are able to work with the language representations of these while others can do so more effectively with images, or the two combined. Although many would attribute the language functions to the left brain and the image functions to the right brain, this is often the province of educated guess-work. What appears to be cogent is not so much the location of the content being processed but the processing capability of the respective cerebral hemisphere. Recently I have tried to explain that integrated brain functions is a more plausible hypothesis, and in support of this position I cited the nature and function of two measures of original verbal images, *Thinking Creatively with Sounds and Words* (Khatena and Torrance, 1973-1981), that I have used in many studies of the creative imagination (Khatena, 1978ab, 1982).

The nature of these tests, in the context of right-brain and left-brain activity, invite some interesting speculation about processing of input auditory-visual verbal stimuli for output as verbal images. *Sounds and Images* presents auditory stimuli alone, whereas *Onomatopoeia and Images* presents stimuli that are at once auditory, visual, and verbal. The listener receives information with instructions to be imaginative and produce original verbal images. When, for example, *Onomatopoeia and Images* is administered, both right-brain and left-brain activity is induced because of the multidimensional stimuli. As input data, the auditory-visual components of onomatopoeic words stimulate the production of right-brain images while their verbal aspects set in motion decoding processes of the left brain to act with right-brain productivity almost simultaneously. Image activity, the province of the right brain, follows.

It includes the use of the imagination in the destructuring, reintegration, and transformation processes, which leads to the emergence of new imagery for transference to the left brain for encoding in language that is ready to be recorded in verbal written form on the response sheet. Because it requires the symbiotic relationship of both halves of the brain in a creative endeavor, such activity is of great value. It calls for the exercise of verbal and image functions that are rooted in creativity (Khatena, 1982, p. 292).

What appears to follow, then, is some high-speed coding-decoding process that involves total brain functioning to find symbolic representation of the image experience in preparation for communication in the language of pictures, words, numbers, musical notations and the like. About 20 years ago, John Eccles of Harvard had suggested that

> Much brain activity has to do with images or re-experiencing of images and their language correlates. Artistic creation of a simple or lyrical kind results from the evocation by association of images that are beautiful, subtle, harmoniously blended and expressed in some language—verbal, musical, or pictorial. Image making of a different order leads to illumination that gives new understanding and insight, and relative to science it may be the formulation of a new hypothesis that transcends the older hypothesis [Eccles, 1958-1972, p. 5].

The same information is stored for retrieval at another time when it may be the basis of other creative acts or discovery consciously or unconsciously precipitated by certain physical conditions or altered states of consciousness.

Images coded in any language system (verbal, pictorial, musical, numerical) become obstructive when they create mental sets that prevent the fluidity so necessary for creative processing. This is a very common phenomenon that prevents many of us from generating or producing the new or seeing things, as it were, in a fresh perspective. What then needs to be done in such instances, is the acquisition of freeing agents or conditions that will thin the blood, dissolve the clot, and restore unimpeded circulation that will surely lead to mental conditions conducive to creative activity. Serious students of the subjects find that there are many ways to induce this freedom and have included states of rest, sleep, drugs, isolation, and hypnosis: one thing all these share in common is in attention to what is happening around or outside oneself so that attention can be turned within oneself (Richardson, 1969).

EXPANDING STUDY OF IMAGERY

The Individual-Environment-Cosmic Imagery System proposed should give perspective to the study of imagery though cosmic influence is in itself rare and at present difficult to verify objectively. However, this ought not to preclude its inclusion as an important dimension of imagery. Recently, Torrance and Hall (1980), in considering the status of measures of creativity, suggested directions that may be taken to assess "the further reaches of creative potential", and the day may come when increased sophistication of our technology will make the objective verification of cosmic influence on the individual engaged in creative activity. Gowan, with the hologram in mind, makes a provocative projection that by reversing the holographic process via integration, one might be able to reach back to the original light source—the cosmic (Gowan, 1980). For the present, we may have to be content to study imagery in terms of the interactive relationship of the individual and the environment.

To achieve some coherence for the study of imagery Richardson (1969), McKellar (1972), Hilgard (1981), and others have attempted to categorize images: the classes in which images have been placed do not differ greatly, and there appears to be general agreement over the class labels of after-imagery, eidetic imagery, and memory imagery; variation in labelling image classes occurs over what Richardson has called imagination imagery under which may be subsumed hypnogogic imagery, perceptual isolation imagery, hallucinogenic imagery, photic stimulation imagery, pulse current imagery, non-drug-induced hallucination imagery, imagery of dreams, imaginative constructions or fantasy, and creative imagination imagery. Differences among them in the main appear not to lie in the phenomenal attributes of images reported but in the antecedent conditions that arouse them (Richardson, 1969).

Researchers of imagery have given much attention to the study of after-imagery, eidetic imagery, memory imagery, and most of the sub-areas of imagination imagery except creative imagination imagery. Relatively little research has been done in this area of imagery, and until a few years ago there was an almost complete absence of experimentally based research into the relationship between imagery and creativity (Durio, 1975). Both Paivio (1971) and Richardson (1969) have pointed out the need to study types of creative imagination imagery, hitherto neglected, and Hilgard's recent article (1981) acknowledges the importance of creative imagination and imagery correlates stating that "any broad discussion of imagery must give attention to the sources and nature of the products of creative imagination" (p. 10). What we need to bear in mind about the creative imagination and its imagery correlates is that unlike the other sub-classes of imagination imagery that depend upon reduction of external stimuli activity on individuals, thus freeing them to attend to an inner world of stimulus events (Richardson, 1969), creative imagination imagery requires the voluntary exercise of divergent or creative mental operations as well, where individuals are not passive recipients of imagery occurrences or flow but active designers and architects of imagery in a problem-solving or reflective thinking set. Let us recall the earlier cited description by Samuel T. Coleridge of imagination as 'primary' and 'secondary', and take note that it is the activation of imagery by the 'secondary imagination' that gives it its creative character to be titled creative imagination imagery—the primary imagination entering in the picture only if the cosmic is prevalent.

One of the major problems of studying the function of imagination imagery has been the lack of objective measures. The early work of Richardson (1969) and a more recent paper by White, Sheehan, and Ashton (1977) bring to notice that self-report measures are among the most widely used for imagery assessment. White and his colleagues suggest, in their conclusion, that the *Betts Questionnaire Upon Mental Imagery* is the most influential of the scales available. Several other measures whose development and construction can be traced to this earlier instrument have promoted a substantial body of research as well.

Betts QMI Vividness of Imagery Scale (Sheehan, 1967) developed by Sheehan is a shortened form of the earlier instrument. A number of studies using this scale have shown that individual differences in imagery vividness are related to such variables as intentional and incidental recall, personality characteristics, spelling ability, creative self-perceptions, improvement of swimming skills, and discriminative reaction time. The *Gordon Test of Visual Imagery Control* (Gordon, 1949) differentiates the autonomous from the controlled visual imagery. Scores on this measure relate positively with stereotyped imagery, reversal rates of the Necker cube, mental disorder, mental practice, paired associate learning, extrasensory perceptions, creative self-perceptions, and the like. The *Vividness of Visual Imagery Questionnaire* (Marks, 1973), the *Imaginal Processes Inventory* (Singer and Antrobus, 1970), the *Questionnaire on Imagery Control* (Lane, 1974), the *Individual Differences Questionnaire* (Ernest and Paivio, 1971), and the *Imagery Survey Schedule* (Cautela and Tondo, 1971) are several other measures that have been used in the study of imagery.

The need for appropriate instruments to study imagination imagery and its correlates in creativity has not ceased and has been, in part, relieved by the construction and development of instruments that attempt to measure creative abilities (e.g. Torrance, 1974). Although Guilford and Torrance did not directly attempt to measure creative imagination in terms of its imagery correlates as such, the measures they produced do suggest that the study of imagination imagery may begin with the study of creative abilities. At least there now exist measures of creative components of intellectual functioning, and these have prepared the way for the study of the creative imagination imagery.

Of particular value to the study of the creative imagination imagery and analogy have been two measures of verbal originality: *Onomatopoeia and Images* and *Sounds and Images* which are the components of a test battery called *Thinking Creatively with Sounds and Words* (Khatena and Torrance, 1973-1981; Torrance, Khatena, and Cunnington, 1973-1981) referred to earlier in the paper. Unlike the self-report instruments that have been widely used for imagery research, these measures require subjects to produce images using creative imagination. The images produced given stimuli in the auditory sense modality can be scored for originality by reference to the published scoring guide, and/or analysed qualitatively as single units, or in groups, or taken as a whole. These instruments have been used as both independent and dependent variables in many studies on the creative imagination imagery (Khatena, 1978ab, 1982). Another instrument that would lend itself to the study of imagery given stimuli in the visual sense modality are the figural forms of the *Torrance Tests of Creative Thinking* (Torrance, 1974), to which may be added a measure of originality using colored shapes in the tactile modality, the *Starkweather Originality Test* (Starkweather, 1971). These instruments move away from a kind of structured introspection required by the self-report instrument to the relatively structured-unstructured projective type instrument in the three generally most used sense modalities (e.g. Khatena, 1975), consequently providing additional resources in the instrumentation for imagery research.

Back in 1969, Richardson observed that only two studies known to him on the creative correlates of imagination imagery had been done, one on perceptual isolation, visual imagery and creativity (Kubzanski, 1961), and the other on the facilitative effects of LSD on the creative problem-solving process (Harman, McKim, Moger, Fadiman, and Stolaroff, 1966). Since then, many studies investigating creativity under conditions of imagination imagery have been published. These studies are instances of investigations of various imagery conditions and creativity, among which are: eye movement, hemisphericity and creativity (Hanard, 1972); hypnosis, creativity, and the imagination (Bowers and Bowers, 1970; Sheehan, 1972); creativity, hypnogogic imagery and relaxation (Green and Green, 1977); aesthetic activities, imagery arousal, and creativity (Lindauer, 1969; Leonard and Lindauer, 1973); unusual visual perspectives and creativity (Torrance, 1972); musical creativity and original imagery (Torrance and Khatena, 1966); personality traits, attitudes, and original imagery

(Khatena and Torrance, 1971, 1973); metaphorical thinking, analogy and imagery (Khatena, 1975b; Schaefer, 1975); imagery of deaf and hearing children (Johnston and Khatena, 1975); imagery of blind and sighted children (Johnson, 1979); imagery in a cross-cultural setting (Khatena and Zètènyi, 1977ab); creativity, imagery, sex, education, and socio-economic variables (Forisha, 1978, 1981) and imagery, language, cognition, and problem-solving (Kaufmann, 1980). To this list should be added those that explored creativity, analogy and imagery as these related to stimulating imaginative thinking, incubation, effects of time press, developmental patterns, sense modalities and autonomous imaging (e.g. Khatena, 1978ab, 1982). Further, several recent doctoral dissertations at the Mississippi State University under my advisement or direction explored retrieval and creative imaging of words, pictures, or both (Cook, 1978); the effects of memory imagery, creativity levels, and differential time allowance (Simon, 1980); the effects of preparation and incubation on original imagery (Parrish, 1981); hypnogogic imagery producing creativity (G. Johnson, 1981); and one master's thesis that explored sense modalities, vividness of imagery, and creative perceptions (Carmago, 1982).

CONCLUSIONS

The proposed Individual-Environment-Cosmic Imagery System is a viable model for giving focus to new directions in research on imagery. Taking the two interactive Individual-Environment dimensions of the model as the most feasible for the present research, leads can be found to researchable problems in the areas of: (1) the nature and function of intellectual-physiological relationships and their bearing on imagery; (2) the activity of intellectual operations (beyond cognition and memory) as it processes imagery both in its original form as well as in its coded language forms; (3) imagery functions in creative problem-solving which calls for the use of all five Guilfordian thinking operations; (4) incubation in the problem-solving mode as vehicle to creative image production that leads to solutions to problems and that relates to scientific creativity; (5) incubation in the reflective mode that relates to artistic creativity; (6) metaphorical dimensions of imagery that are involved in scientific and artistic thought and works; (7) imagery as schemas of personality differences indicative of individual character, and total mental functioning; (8) imagery functions of eminent men and women in their acts of creativity; (9) imagery in cross-cultural situations in and out of this country; (10) cerebral hemispherical functioning, intellectual processing, and imagery correlates; (11) intellectual operations and imagery as functions of age and sex; and (12) imagery, periodicity and transformation. Other important and related directions of research lie in the development of psychophysiological measures that are sensitive to intellectual activity on imagery, measures that go beyond self-reports to production of imagery as objective evidence that at one and the same time contain information of the subjective and private worlds of the individual at work, and improved designs and methodology that will allow for experiment while controlling extraneous variables. Last but not the least are areas of study that may investigate the practical application and value of theoretical findings in educational and mental health settings, with a variety of populations along continua of mental, emotional, and physical variability in different socio-cultural settings.

The intriguing dimension of the cosmic is at present illusive to study. However, behavioral-humanistic scientists, by taking cues from the testimonies of great people whose creativity have been fired by cosmic forces, may key their energies to invent the instruments and methodologies for the exploration of this dimension of human potentiality. Man's creativity has time and again extended known parameters of knowledge way beyond the outer limits and put in his grasp what was before unknown: it may be that common pursuit of the uncommon will one day give him the ingenuity and power to transcend the tantalizing situation and place within reach the cosmic.

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Curriculum Design and Neuropsychological Development

CONRAD F. TOEPFER, JR.
State University of New York at Buffalo

Efforts to improve the effectiveness of learning activities across the spectrum of elementary and secondary education are reflecting an increasing fascination with neuroscientific research. To say that any systemic curriculum design has emerged which is based upon the myriad of growing findings in the range of quadrants in such neuroscientific research would be in error. However, the validation of these data in a growing number of areas means that responsive curriculum development must increasingly hold existing curricula up to scrutiny in the light of these findings. It is important that such introspection separate the fact from the folklore in defining in what ways curricula should respond to the neurological realities which are extending understandings in neuropsychology. As this occurs, the improvement of teaching and learning through curricula for youngsters may enter a dimension of responsive effectiveness beyond any successes of the past.

THE CONCERN OF CURRICULUM DESIGN

Curriculum planning and development is a recent discipline in the educational field. While educational historians cite the efforts of Bobbitt (1918). Charters (1924) and McMurry (1924) in concerns over organizing content and activities. the "modern" development of process in curriculum planning is attributed to the work of Caswell and Campbell (1935). Their concern with the planning of program and learning activities based upon learners' capacities initiated greater focus upon the role of learning psychology in organizing curricula and school programs. Burton (1944) further emphasized the need to plan curricular experiences upon principles of learning. His use of the term "design" became the frame for the subsequent concerns of curriculum and instructional design. The work of Tyler and the so-called "Tyler rationale" developed a model for curriculum design (1950) which continues to be the basis for curriculum design in American education. This model seeks to improve the interrelationship of components such as objectives, content, activities, materials and evaluation devices in terms of a number of screens, including principles of learning. The Tyler rationale derived significant aspects of its focus on principles of learning from the author's interaction with Virgil Herrick in a curriculum theory conference held in Chicago in 1947. Their editing of papers presented at that conference (Herrick and Tyler, 1950) built from Herrick's paper, "The Concept of Curriculum Design" and Tyler's work, "The Organization of Learning Experiences". Their collaboration brought an increased interest in the curriculum field, not only on the learning experiences of students as a base for developing subsequent learnings, but the styles and capacities of children to learn at differing stages of childhood and adolescence.

The literature and practice of curriculum planning moved toward more succinct consideration of learning principles as a basis for curriculum design. Krug (1950, 1957), Saylor and Alexander (1954), as eminent theoretical curriculum generalists, set the stage for consideration of the more studied application of learning principles at specific levels. Representative of such efforts were the important works of Ragan (1953) in elementary curriculum, Noar (1953) in junior high school programming, and Alberty (1953) in secondary curriculum reorganization. Interesting gains were made in refining instructional programs. These accomplishments saw the more effective relation of instructional objectives with content, activities, materials and measuring devices in terms of learner skills and capacities.

The continuation of this movement in the curriculum field was sharply counteracted by the impact of "Sputnik" in 1957. Emphasis on content and its mastery above considerations of learning psychology gained favor despite the successes in more holistic curriculum development which were achieved in recent years. The nation's schools were soon inundated by a host of content packages primarily in mathematics and science, but with some in English language-arts and the social studies as well. Virtually all such packages were created by academic content specialists with little or no involvement of educators or learning specialists grounded in how children learn. SMSG mathematics, BSCS biology, chem. study and bond and PSSC physics programs appeared on the secondary school scene and soon became the models for packages at elementary and middle grade levels. Taba's concerns (1962) to design curricula in terms of the nature of the learning process and the holistic needs for education were largely lost in the search for more scientifically organized content as a basis for curriculum development.

By the mid-1960s, curriculum writers were indicating the need to return to more process-oriented planning of instruction based upon learning principles (i.e. Saylor and Alexander, 1966). However, response to such calls appeared to be slight. Even the works of a learning specialist as eminent as Jerome Bruner (1965, 1966) had relatively little impact on the infatuation with content, of and for its own sake, in curriculum building. J.M. Stephens' psychological examination (1967) of the process of schooling reinforced the need for curriculum planning to utilize content as a means to valid educational ends based upon second learning principles and the capacities of youngsters to learn, but again, largely to no avail.

While the humanistic curriculum movement attempted to base content upon human and social needs it did not adequately focus on the basic psychological principles of learning. Raths' early work in needs theory had been grounded in response to both learner needs and learning principles (Raths and Burrell, 1951). Raths' re-definition of the importance of principles of learning psychology (1969, 1972) built the strongest case to return to the kinds of progress in improving curriculum design initiated in the early 1950s. Contemporary efforts attempting to improve the role of learning principles in curriculum design have been enhanced by the works of Unruh (1975) and Doll (1978). Efforts in the area of instructional design, however, have not been based upon the principles of learning psychology. To a large degree, they have developed an interest in manipulating content and information in terms of the increasing technocracy available through data processing innovations. It has remained for the relation of curriculum to learning and how that takes place to be spurred on by an even more exciting area of discovery, the neurosciences.

NEUROSCIENCES, NEUROPSYCHOLOGY AND CURRICULUM

The adequacy of response to the knowledge explosion in the neurosciences stands as a critical issue. Fads or "pop" practices in schooling have long been a problem faced by responsive curriculum planning. Innovations within traditional pedagogic areas have required pilot projects and reworking of practice to refine new departures which could become means for effective curriculum improvement. The advent of an era in which substantive information from a wide range of areas beyond the pedagogic frame is viewed as appropriate to change school programs and influence curriculum design, poses serious difficulties. At the present time, the vast majority of those responsible for curriculum planning and development in American schools have no credentials in the areas of the neurosciences. Likewise, neuroscientists interested in applying areas of their findings to educational and schooling approaches are almost universally ignorant in the areas of curriculum planning, development and design. The problems of developing curricula and programs on the limited perspectives of either educational planners or neuroscientists grounded only in their own expertise warrant serious consideration. Short of the updating of credentials of specialists in both areas, a need to develop teams of curriculum designers and interested neuroscientists appears to be the most viable solution to this dilemma.

The range of areas in which neuroscientific discoveries have potential implications for educating children is staggering. Yet it becomes imperative that educators resist the temptation to implement tentative programs based upon such interesting ideas until an adequate basis of study by curriculum planners and neuroscientists in those respective areas has been undertaken. The need to pursue such a course of action stems from the possibilities that many traditional principles of learning psychology may gain a specification and validation which could substantially improve learning beyond what presently accrues. Because of this, the fascination of professional educators at all levels has caused a needed increase of interest and concern with the principles of learning psychology in the organization of classroom experiences in schools. From this it is hoped that the psychology of learning will include expertise in neuropsychology in redefining its own body of principles of learning. The syncretism of learning psychology with neuropsychology based on a careful study of the range of neuroscientific discoveries may well be the best way to improve school programs. This would allow the traditional interaction of curriculum designers and the neuropsychologically competent learning psychologists to work at responsive curriculum planning and improvement of instruction in the school setting.

Some Promising Areas

This author has been interested in the potential of specific aspects of neuroscientific discoveries in improving teaching and learning in schools. As a curriculum generalist with no professional credentials in neuroscience, it has been necessary to embark on a serious program of reading and personal study in these areas. This has culminated in collaboration, interaction and study with individuals competent in neuroscience areas. The idea of teaming, described earlier, has proven the most efficient way for this writer to develop a perspective and access to a responsible base of neuroscientific reality to make suggestions for responsible curriculum design. While other areas of neuroscientific discovery are tempting to consider as a basis for generalizing about possible changes in school program, this writer has felt that integrity demands confining suggestions for improving curricula to those areas in which this shared experience with specific areas of the neurosciences has been adequately facilitated. The major area of interaction has been in brain growth periodization and a second, less experience-based area has been in cerebral lateralization and dominance. The concerns for curriculum design in these areas have stemmed from identification of implications for cognitive development of youngsters based upon these areas.

BRAIN GROWTH PERIODIZATION

Experience in examining learning profiles among students has long revealed that intellectual, cognitive growth vacillates. Yet, vertical curriculum organization across the elementary, middle and high school years has assumed a continuum of learning, and thus, of mind and brain. It is not uncommon to observe that at several points in a learner's public school career, even highly able, motivated and achievement-oriented youngsters suddenly come to a "dead stop" in their cognitive, "learning tracks". Individual frustration and self-doubt at these points of dramatic reversal of their previous capacity to learn successfully is not feigned for attention, peer approval or other purposes. In such circumstances, concerned teachers may attempt to alternately raise and lower challenge, demands and expectations for achievement. Such attempts are, more often than not, futile and study shows that such youngsters enter a period ranging from four to as much as nineteen months in which they seem to lose their capacities to move to higher cognitive levels. Following these low growth periods, many youngsters appear to leap into a period of almost unbridled increase in cognitive skill. In these instances, the learner seems to make a sudden shift in "learning gears", largely independent from any new cognitive strategies by teachers or departures in the curriculum as designed.

While long puzzling to teachers, curriculum design has found few sources suggesting causal or correlating episodes to explain such phenomena. The concept of learning stages (Inhelder and Piaget, 1958) was helpful in relating such achievement episodes to the years of early childhood through age 10 and 11. However, since not only Piaget's initial studies but most of the work under his leadership focused on populations of younger children, the so-called "Piagetian stages" were not really helpful in explaining episodic cognitive growth of youngsters after age 11. Circumstances brought about the opportunity for this writer to collaborate with Herman Epstein in his work in brain growth periodization. A biophysicist with special interest in developmental neurobiology, Epstien (1970, 1974) was seeking the opportunity to work with the implications of the scientific facts of brain growth periodization for improving teaching and learning through curriculum design. This work of the past five years has helped to bring experimental and pilot school programs based on these data into operation. The results of these efforts have suggested a model for the systematic involvement of neuroscientific findings into responsive curriculum improvement (Epstein, 1981). From experimental beginnings, a total school system is now initiating a pilot curriculum for grades kindergarten through 12 based on brain growth periodization (Cramer, 1981) which will provide solid experimental versus control group findings.

The Facts of Brain Growth Periodization

Curriculum design in American schools reflects an assumed faith in a constant continuum of growth of mind and thinking capacities of children in school. Organization of subject matter for such learning reveals a concern for gross, quantitative cognitive growth of learners across their years of schooling. To that end there is, at best, minor recognition of changing mental capacities of learners with regard to differences of learning modalities possible at specific ages. While teachers may respond to changes in learners' thinking capacities in their own classes, expectation for quantitative growth in mastery of information and cognitive skill development across the spectrum of the public schools gives little indication of such awareness in curriculum design. Unfortunately, the impact of Piagetian findings has had similarly little change on the emphasis of how young children may learn at various age frames. This writer (1980) contends that the interface of Piagetian with Epsteinian data may combine to create the development of public school curricula far more responsive to the intellectual realities experienced by children as they progress through the years of schooling.

Brain growth periodization findings refute the idea of a constant continuum of growth of brain and thinking capacities.

These data have appeared in the interface of research in the areas of anatomy, biology and developmental neurobiology to confirm that the brain, like other organs, does grow in stagewise fashion (Epstein, 1974). In this concept of phrenoblysis, Epstein established the rhetoric of the plausibility of human mental development stages based upon the reality of special brain and mind growth periods. The fact of brain growth periodization is that the brain experiences highly chronologically predictable growth stages. During a growth spurt period, the organ is developing capacity for higher level functioning and the initiation of higher level capacities during that period. The Epstein findings also confirm an alternation of periods of growth spurt with growth plateau stages which create an interfaced pattern of periodization in the growth of the brain. Epstein (1977, 1978) has specified this through correlation of data from a range of existing researches including mental age development and the physical development of the brain.

Eighty-five to ninety per cent of youngsters of average and above ability experience periods of great brain growth at some point during each interval of ages 3-10 months, 2-4, 6-8, 10-12 and 14-16+ years. Epstein (1979) observes that the first four of these brain growth stages are on the onset of the classic Piagetian stage as researched by Arlin (1975). This is *not* to assume, for instance, that on the dawn of the sixth birthday a youngster begins a twenty-four month period of unbridled brain growth which comes to a screeching halt on birthday eight! The reality is that eighty-five to ninety per cent of these youngsters will experience their personal brain growth spurt at some period of time during that age 6-8 years interval. A similar percentage of youngsters will experience a plateau in their individual brain growth at some interval during the age 4-6, 8-10 and 12-14 years periods.

Before considering curriculum design implications of this periodization pattern, some consideration of the nature of both the growth spurt and growth plateau periods is in order. The issue of the relationship of the growth of the brain to the function of mind and learning is central. Epstein (1980) stated that cell replication in the brain, as measured by DNA synthesis, terminates at about age 18 months, meaning that the last four brain growth stages occur without any increase in the number of brain cells. Epstein contends that this increase in brain size is accounted for by a very substantial increase in protein per brain. For neurons, this increase in protein is manifested in the elongation and branching of axons and dendrites. Thus, there is a strong reason to expect a substantial increase in the complexity of neural networks in each of the last four brain growth stages (ages 2-4, 6-8, 10-12 and 14-16+ years). This could correspondingly express itself in a substantial increase in the complexity of the thinking processes of the brain.

Huttenlocher (1979) has established that children at age 2 have higher density of synapses per cubic millimeter of cortical brain tissue than adults. While scientists had previously thought that density of synapses increased with age, his data confirm that the synapses shift during periods of brain growth. The increase of cognitive ability during the brain growth stages also infers the possibility of maturation of synapses during the brain growth stages found by Epstein. Huttenlocher's data were gathered through a special electron microscopy technique to perform post-mortem analysis of frontal cortex cells. His findings also confirm that dendritic growth continues, even though the number of synapses per neuron declines. Thus dendritic growth continues during the brain growth spurt periods.

Epstein (1980) has found there is virtually no growth in the brain mass and no significant increase in the complexity of neural networks during the brain growth plateau periods at ages 4-6, 8-10 and 12-14 years intervals for from eighty-five to ninety per cent of youngsters. This reversal of the patterns found in the growth spurt (age 2-4, 6-8, 10-12 and 14-16+ years) periods should give serious reason for re-thinking curriculum design and our expectations for how and what children can learn during the intervening brain growth and plateau periods.

Implications for Curriculum Design

Curricula should differ in learning expectations for learners during intervals of brain growth and plateau of growth. Epstein (1977), Epstein and Toepfer (1978), and Toepfer (1979) contend that initiation of new and higher level cognitive processes should have greater probability for success when undertaken during periods of brain growth. The assumed extension of neural network during those times predicts this. On the other hand, it appears that learning which stresses the continued introduction of new and higher level cognitive processes will be far less successful during brain growth plateau intervals. A lack of continued extension of neural network during these intervals also reinforces this prediction.

Epstein (1977) correlated the existing research of Eichorn and Bayley (1962) and Shuttleworth's investigation of mental age growth profiles (1939) with the brain growth periodization stages. Head circumference growth and mental age growth profiles both correlate highly with brain growth periodization. In the latter, youngsters experience as much as 38 months of mental age growth in some brain growth biennial periods and as little as 7 months of mental age growth during some brain growth plateau periods. From the mental age growth data alone, curriculum designers should have seen the need to vary expectations for quantitative cognitive growth in children at different ages. The nature of these data suggests that during the brain growth periods, curricula should challenge youngsters to develop reasonably higher cognitive skills. These cognitive skills can, of course, be used to learn facts and information. Thus the learning of appropriate facts and information can be combined with movement to new and higher cognitive levels during brain growth spurt periods. During more fallow periods, however, the difficulty which most youngsters experience in initiating new and higher level cognitive skills, in what now is shown as periods of plateau in brain growth, requires serious consideration. This is not to say that facts and information cannot be successfully processed during these plateau intervals. Since most youngsters find movement to newer and higher level cognitive levels difficult during plateau times, facts and information can be learned with great success if they are taught within the profile of thinking skills initiated *prior* to the onset of the plateau.

This means that during plateau periods, both fact and information can be processed as well as consolidating, refining, and maturing those cognitive skills initiated prior to the onset of that particular plateau period. Thus the appropriate design of learning experiences during such times can make the learning of fact and refinement of skill during plateaus a very rich experience. Beane, Lipka and Ludewig (1980) state that success in learning is strongly related to the development of clear self-concept and positive self-esteem. Students who refine these components of self-concept and esteem partially through success in school during brain growth periods often find self-concept muddied and self-esteem negated by poor success in school during plateau period intervals.

Identification of progress through cognitive levels by individuals in their personal synchrony of growth stages and plateau periods requires instrumentation. Earlier use of the Ankney-Joyce (In Sund, 1976) test to identify readiness to move from concrete to formal operations has been expanded in newer instruments by Lawson (1978), Tobin and Capie (1980) and Arlin (1981). These instruments are providing more refined means to identify readiness of learners to move to curricula designed to differentiate upon their capabilities as learners during appropriate growth and plateau stages.

The Reality of Cognitive Levels

Epstein (1980a) presents an expectation of the percentages of youngsters who can think at particular cognitive levels at a range of school ages. Table I shows the percentages of learners who can be expected to think at specific levels at a given age.

As stated earlier, the first four Epsteinian stages are also the turning point for classical Piagetian stages while the final brain growth correlates with Arlin's thesis (1975) of a fifth Piagetian stage. In Table I we can see that in early childhood and elementary school years, learners need curricula which facilitate the initiation of concrete operational thinking and then mature that modality from the onset stage at the end of those years.

Middle grade youngsters in the age 10-14 years period require curricula which gradually build through maturation of concrete operations and, for some, provide beginning learnings in onset formal operational thinking. High school curricula,

TABLE I: *Percentage of Children at particular Cognitive Levels**

Age (years)	Pre-operational	Concrete onset	Concrete mature	Formal onset	Formal mature
5	85	15			
6	60	35	5		
7	35	55	10		
8	25	55	20		
9	15	55	30		
10	12	52	35	1	
11	6	49	40	5	
12	5	32	51	12	
13	2	34	44	14	6
14	1	32	43	15	9
15	1	14	53	19	13
16	1	15	54	17	13
17	3	19	47	19	12
18	1	15	50	15	19

*Adopted From Epstein (1980a).

then, should seek to challenge youngsters during the age 14-16+ brain growth stage to move from the onset and maturation of concrete operations upward and into formal operations to the degree possible for individual learners. Across the spectrum of elementary and secondary curricula, learning opportunities can be planned around the epochs of brain growth spurt and plateau periods to meet a readiness for learning which traditional schooling has never specified in its belief in the continuum of brain growth. Vertical curriculum organization can be far more effective in meeting learning capacities of youngsters as they pass through their profile of brain growth periodization and organize far more responsively effective learnings than existing practice has achieved. The substantially lower cognitive achievement of youngsters in the age 8-10 and 12-14 years plateau periods supports this contention. Elkind (1981) has identified that the expectation of cognitive skill demanded in the high school is quite unrealistic in terms of the actual cognitive capacities of a substantial number of adolescents. It appears that many learners are left behind, in their middle-grade years, in a shift from curricula working at concrete operations to learnings at beginning formal learning operations, for which only a minority of youngsters have readiness.

The data presented in Table I were organized from studies reported by Shayer, Kuchemann and Wylam (1976) and Shayer and Wylam (1978). These data indicate that the movement to formal operations after age 10 is far more gradual than most Piagetians have assumed. Brain growth periodization findings suggest that middle-grade curricula, to be responsively effective to the cognitive capacities of youngsters between age 10 and 14, must be organized in synchrony with what the Epstein findings identify. The improvement in such pilot efforts have been encouraging. The learning of facts and information and the maturation of skills initiated prior to the age 12-14 plateau interval during that time has improved over the previous, traditional approaches.

The "Turn-Off" Syndrome

The failure of existing curricula to move out of expectations for continuing successful initiation of new and higher cognitive-level skills during the age 12-14 years plateau interval prompted an examination of achievement during that interval. Initial reporting of the extent of this learner difficulty was discussed by Epstein and this writer at the 1979 meeting of the Association for Supervision and Curriculum Development. In reporting this information, *Education U.S.A.* (March 12, 1979) referred to this as a "turn-off" syndrome. These data were fully reported (Toepfer and Marani, 1980) and showed that academic achievement problems were initially experienced by many learners for the first time between age 12-14 years. Among large numbers of students in IQ ranges of 90-100, 100-110, 110-120 and 120+, who had earned no grades lower than B− prior to age 12, the numbers earning grades below C− for the first time during their age 12-14 years interval were staggering. The percentages for each of the respective IQ categories just identified were twenty-four per cent, thirty-four per cent, thirty-six per cent and thirty per cent, respectively. This was based upon a sample of 1,000 students in each IQ category.

The term "turn-off" was utilized because the numbers of these learners who experienced initial achievement difficulties during their age 12-14 years school experience and failed to reverse this pattern of achievement during their age 14-16+ years brain growth spurt interval was even more alarming. The percentages of those youngsters who experienced such initial learning difficulties in that time frame, who never reversed their school achievement, were, respectively, seventy-four per cent, eighty-two per cent, eighty-seven per cent and eighty per cent. These data prompted a follow-up study in two geographic areas which found amazingly similar results (Toepfer, 1981). In the face of such data and the previously reported findings of Elkind (1981), the nature and difficulty of challenge presented in existing middle-grade and high school curricula may, indeed, be more unrealistic in terms of neuropsychological principles of learning and characteristics of learners at different stages of development. In the case of the 120+ IQ youngsters, Shayer *et al.* (1976) found a similar problem among high-ability learners at these ages in British secondary schools.

In its simplest interpretation, the curriculum design must examine the readiness of learners to move on to higher cognitive levels. The data of brain growth periodization give important clues to this readiness (Epstein 1980a). Epstein (1981) synthesizes earlier concerns (Epstein and Toepfer, 1978) that IQ is not the major premise upon which such readiness should be anticipated. He cites that the Piagetians' achievement of accurate reasoning development descriptions does not provide curriculum planners with means to foster such improvements in school programming. His discussion of Hunt's (1961) concerns of the problem of match of learnings to capacity should cause us to remove some of the implicit faith we have placed in IQ as the indicator for such readiness. This warning is an important one for those exponents of improving curricula for gifted and talented youngsters who see IQ as a means for such identification. In this respect, the work of Webb (1974) is very important. His work with large numbers of 150+ IQ youngsters between age 6-11 years reveals that their readiness to handle formal operations challenge is not substantially different from the ages at which the more normal IQ range learners demonstrate this capacity. In the light of such findings, curriculum designers seeking direction from neuroscientific findings must recognize that IQ, in all probability, refers to the rate which a youngster can learn something new but not necessarily to his cognitive skill level. In examining both IQ and cognitive skill level, these two areas may suggest means for developing more effectively responsive curricula based on the cognitive readiness of learners at different chronological ages.

This writer considers the findings in the brain growth periodization to have the greatest impact for matching curricula with children. The interaction of neuroscientists with learning psychologists, curriculum specialists and others has provided a basis of experimentation in school settings not as systematically affected in other areas of neuroscientific investigation. While such findings may have impact as great or greater for curriculum design, the interaction of educators with persons leading such scientific investigations is, at present, critically lacking. Curriculum designers can now find in the latest work of Shayer and Adey (1981) a work which can serve as a model for matching cognitive development and curriculum demand. Its basis upon and interaction with the brain growth periodization data should be most helpful in organizing learning experiences which respond to the readiness of learners at different stages.

CEREBRAL LATERALIZATION AND HEMISPHERIC DOMINANCE

While it is a more popular and generally known area, the lack of specific interaction of neuroscientists, learning psychologists and curriculum planners to study data about cerebral lateralization and hemispheric dominance makes its implications for improving instruction in schools far more tenuous than in the area of brain growth periodization. This author has had far less involvement in this area of neuroscientific development than with brain growth periodization. However, that interaction causes an enthusiasm that discoveries in this area may be eventually as important to the application of neuropsychology to curriculum design. Some implications are noteworthy for consideration by curriculum designers, at this point.

It is a fact that the traditional tasks of schooling center on linear, sequential, verbal, analytical, explicit and logical operations. All of these are skills dominant in the left hemisphere of the brain. Youngsters who are preferential in their evolving styles of learning to right-hemisphere-dominant capacities excel in learnings oriented toward spatial, simultaneous, holistic, visual-spatial, tactile and intuitive skills. The biases of schooling do mean that, more often than not, the right-hemisphere-dominant learners find that schooling organizes learnings and rewards the achievement of students with dominance in left-hemisphere skills. In a sense, right-hemisphere-dominant learners often "cannot learn in the way that the curriculum is organized and implemented in classrooms".

Kinsbourne and Hiscock (1978) present a synthesis of the data in this area which should be basic for any considering the reorganization of present school curricula. Gazzaniga (1974) presents important basic data on the relationship of cerebral dominance to decision-making which has implication for re-thinking various aspects of public school curriculum organization. The dangers in second-hand interpretation of even such exciting data is a critical problem facing curriculum design. This can only be avoided by specific interaction of curriculum designers and learning psychologists with the neuroscientific investigators themselves. This also predisposes that the neuroscientists have the time, interests and inclination to interact with those concerned with the practical applications of implications of their findings. To that end the interests and achievements of Bogen (1975) in the educational implications of hemispheric specialization may be a basis to begin such dialogue.

Implications for Curriculum Design

Any study of the primary implications for curriculum design based on hemispheric specialization must consider Lenneberg's premise (1967) that hemispheric dominance and specialization is not completed until puberty. Thus the years of early schooling combined with enlightenment of parents about youngsters who exhibit left-handed preference (indication of right hemisphere predominance) need careful reconsideration. The world discriminates against left-handedness. Table manners, scissors, bottle caps, pencil sharpeners, desks and handwriting (with chairs with right-side writing boards!) all bring discomfort and stress to children with left-handed tendencies.

Early childhood education must organize an environment for learning which removes as many of these barriers as possible. A curricular goal here would be twofold. First, the elimination of barriers to learners displaying learning preferences in either hemisphere is essential. Second, school curricula should seek to work within the hemispheric preference of the learner as well as to facilitate individual growth in learning experience in the non-dominant hemisphere. This might lead to the development of more integrated learners with better processing skills in each hemisphere. Team teaching may be one viable means to facilitate this for young learners. Traditionally, teaching teams have been organized on the preferences and common strengths of teachers to the end that it is predictable that most teaching teams are composed of individuals with similar hemispheric learning preference. The non-biased educational environment recommended here for young children entering school settings would be frustrated by such teaming arrangements. Riegel (1981) recommends that schools for young children should be staffed by teaching teams combining a teacher with right hemisphere dominance with one having left hemisphere dominance. This would require staff development and curriculum planning activities which could allow such teams to function successfully with a mixed group of youngsters in terms of their early hemispheric preference. Most important, such a setting would provide all learners with models for learning which responded to learning preferences in either hemisphere.

From birth, the infant must develop left hemisphere specialized skills to build upon the right hemisphere spatial orientation to his pre-natal environment. Almost in a "Promethian" sense, rapid development of left hemispheric perceptions "unbind" the child from spatial existence prior to birth. Initially, the baby cries when mother leaves the room because the world to the infant is bounded by sensory perception. As left hemisphere perception tells the infant that mother always returns to his world, some understanding of a world beyond the infant's vision grows. This growth of the youngster continues as individual preferences for learning develop to the point when the youngster begins formal schooling. Reading readiness and the need to read constitute a bias against which reality of learning needs and schooling practices continue to joust. School continues to force too many children to read before they have either need or readiness. Educators fail to communicate to parents that learning can proceed without reading. Sound learning experiences can be organized through right hemisphere-oriented skills involving auditory and visual-spatial input which use holistic, spatial lateral and other skills. Discussion, visuals, video tape, manipulation can all provide sound learning for youngsters not yet ready or inclined to begin traditional reading programs. The curricula must be expanded to provide such opportunities for youngsters not yet ready to enter a learning process which initiates upon left-hemisphere readiness and preference.

While girls demonstrate earlier readiness for reading more often than boys, eventually boys achieve considerably beyond girls in the ability to abstract from concrete experiences. This may stem from the fact that as soon as girls demonstrate reading readiness they move into that learning activity while boys develop a greater right-hemisphere concrete background in spatial and other dimensions. Although teaching of reading in English involves a linear, symbol system, reading is not solely a left-hemisphere function. Another suggestion of Riegel (1981) is to wait a year to initiate formal reading instruction after reading readiness has been identified. During this interval, emphasis could be put upon developing appropriate right-hemispherically perceived experiences to develop a richer visual-spatial, holistic and intuitive reservoir. Upon this basis, the initiation of reading, with full readiness, might facilitate more meaningful learning through reading.

Elkind's term, "the curriculum disadvantaged learner" may apply to learners with other than left-hemisphere preference faced by a curriculum oriented for the most part to left-hemisphere learning and processing. The experiences of young children in learning vocabulary from a right-hemisphere perceived experience or a visceral "midbrain" or limbic system experience

(McLean, 1978) is another example of how curriculum in schools for young children could organize to broaden concrete experiences. Children understand "red", "cherry", "yellow", and "lemon" to an initial degree not possible when teaching such "experience-barren" ideas as "fair", "honest", and "justice". The experience base of learners must be considered beyond such separate areas as "Head Start" and other early intervention projects for the supposedly disadvantaged. All learners need consideration of how curriculum expectation requires an appropriate experiential base.

The resultant deeds of learners proceeding from this indiscriminate base of early learning into the high school is also considered by Riegel (1979). While middle-grade and secondary school curricula must consider alternatives to existing left-hemisphere preferred learnings, it is quite clear that such "pound-of-cure" approaches will be minimally helpful to students presently at those levels. The impact of hemispheric specialization must be to develop curricula from the onset of schooling onward which are preventive to the kinds of problems Riegel has found among adolescents. To that end, the systematic interaction of researchers in this area of the neurosciences with learning psychologists and curriculum designers is an absolute essential. For that reason the true implications of hemispheric specialization for curriculum design remain relatively "soft" and will require lengthy study before specific changes in school programs can be undertaken in anything more than a cavalier fashion.

SUMMARY

Specifying the results of the plethora of investigations of the neurosciences to refine the tenets of learning psychology into a responsive neuropsychology of learning is a staggering idea. Yet, the kind of interactions among specialists cited here seems necessary to identify means to progress rather than mere change of existing curricular practices. Another consideration is the degree to which the information base of teachers in service and through pre-service efforts must focus upon the neurosciences and neuropsychology. Aside from the education of psychologists and curriculum planners, the perspective of the teacher as the "ultimate" curriculum planner must specify what information teachers must know to improve learnings in the classroom.

In the face of this Herculean task it is important not to lose sight of the significant ways in which curricula and the quality of learning for students can be improved through the refinement of these explosions of knowledge in the neurosciences. However, the separation of fact from fancy must be undertaken carefully to guarantee improvement rather than further confusion in the design of learning experiences. The two areas of neuroscientific study considered here are critically important to the needs for instructional improvement. Certainly other areas of the neurosciences have their own areas of contribution. While considering the range of these exciting possibilities, we must not fail to improve upon past assumptions as to how children learn. Learning is a journey rather than a destination. If the journey begins in the wrong direction or with an inappropriate curricular vehicle, that journey for the individual may be less than prosperous, or aborted. Traditionally, we have given students two freedoms, the right to agree, and the right to be wrong. Our efforts to understand the educational implications of the increasing knowledge of the previously unchartered realms of the brain and mind may hopefully expand those freedoms to include rights dealing with opportunities to learn in the fashions through which each child can best succeed.

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Art and Music as Stimulants to Right-Hemisphere Imagery and Creativity*

JOHN C. GOWAN
San Fernando Valley State College, Northridge, California

Progressively in the last several decades, art and music have tended to drop out of the curriculum on the grounds that they were "frills". Recently, some very powerful new research and theory has surfaced which appears to indicate that art and music may be far more important than had previously been realized, since they may contribute to the development of the right-hemisphere imagery, and hence to creativity. This paper will try to describe the research and connect it to classroom implications.

First, we need to review a bit of physiology. The quotation is from Gowan, 1975: 261:

> The brain is composed of two cerebral hemispheres, each of which governs the motor activities of the other side of the body. The two hemispheres appear to work as dual controls, being joined by a massive conduit of nerves known as the *corpus callosum*. About 1950 Myers and Sperry discovered that if the *corpus callosum* were cut, each hemisphere could function independently as if it were a complete brain. This discovery led to a number of intriguing questions such as what are patients like who have had this operation? and are there differential hemisphere functions?
>
> Sperry and Gazzaniga (Gazzaniga, 1957) conducted tests

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> to show the differential function in split-brain patients. These showed that for some reason, the left side of the brain quickly assumed the normal functions of speech and writing and that the right side was unable to speak and write. The right side, however, is not without intelligence. When a patient feels fruit with his left hand in a photographer's change muff in which there are (for example) two apples and an orange, he cannot say what the fruit is, but he can signal that the two apples are alike and the orange is different. The right hemisphere of such patients also handled spatial relations better than the left. It also appears from other research to handle holistic concepts and creative imagination better.

Whereas the left-hemisphere function is primarily Guilfordian convergent production, the right-hemisphere function is primarily Guilfordian divergent production. Thus the right-hemisphere imagery is the vehicle through which incubation produces creativity. The implications of this simple statement for educational change are enormous.

The seat of this imagery appears to be in the Wernicke area of the right cerebral hemisphere (Jaynes, 1976: 109). While it was once thought that special means were necessary to elicit it, it has lately appeared that the process (like the shining of the stars) goes on all the time, but, during our waking hours under most circumstances is overlaid by the more cognitive processes of the generally dominant left hemisphere. These involve the handling of incoming perceptual information and its processing into thought and action via language, and the continual stream of internal discourse which accompanies consciousness. Remove both of these activities from the left-hemisphere function through relaxation, meditation, hypnosis, fantasy, day-dreaming, sensory deprivation or some similar state, and the imagery of the right hemisphere is brought into focus at once. Since speech and writing are confined to the left hemisphere, most educational processes educate only this half of the brain. Wallas (1926), in his paradigm for creativity, called this aspect "preparation", and clearly indicated that it was the necessary, but not the sufficient, condition for creative illumination. The sufficient condition is, of course, incubation, which was Wallas' term for the relaxation which produced the right-hemisphere imagery.

We have a good repertoire of educational techniques of preparation (e.g. Williams, 1970; Meeker, 1969), but we lack equally strong techniques for incubation. *Thinking Creatively with Sounds and Words* (Khatena and Torrance, 1973) is one of the few devices in this area.

It is already obvious that one of the imminent curriculum changes in schools for the gifted will be more attention paid to incubation techniques. These techniques relax the usually dominant left hemisphere function through dreaming, day-dreams, drugs, fantasy, meditation, hypnosis, diversion, play, and sensory deprivation. The left-hemisphere cognitive function appears to require two conditions: (a) continual sensory input, and (b) continual internal discourse.. Any of the previous techniques appears to allay the left-hemisphere function through cutting down one or the other of these dual inputs. While researchers have known about such techniques for a few years, their widespread use in schools had been handicapped because of the religious, moral, legal, or social sanctions against some of them.

The previous approach has been mainly a negative one: cut out the activity of the dominant left hemisphere, and imagery will automatically appear in the right hemisphere (since it goes on there all the time, but is ordinarily not paid attention to). But the new approach is more positive. Find positive activities (i.e. art and music) which stimulate the right hemisphere directly, despite activity in the left. Let us follow this approach further.

The use of art and music education, not only for their own sake, but to stimulate the right-hemisphere activity, and hence improve creative function has been mentioned by a number of writers. Williams (1977) in an article on "Why Children Should Draw" points out that art stimulates a child's curiosity. He quotes Houston: "Verbal-linear-analytical intelligence is a small part of the intelligence spectrum. There is also visual-aesthetic-plastic (working with the hands) intelligence. . . ." This right-hemisphere intelligence is what in an earlier day Lowenfeld called "haptic", and what Prof. Ferguson (1977) calls "thinking with pictures" which he believes is an essential strand in the history of technology development, although presently neglected in scientific education.

Again, to quote Williams:

> The differentiation of the brain into left and right hemisphere certainly plays a role in arts-centered learning. . . . A child without access to a stimulating arts program, according to Houston, "is being systematically cut off from most of the ways in which he can perceive the world. His brain is being systematically damaged. In many ways he is being de-educated."

Williams then cites a number of elementary schools where an enriched arts program has improved general performance.

Jaynes (1976: 364-9) devotes several pages to the importance of music and musical instruction in stimulating the right-hemisphere. After citing a number of authorities and facts in support of the special relationship of music to the right hemisphere, and hypothesizing (after experiments on neonates) that "the brain is organized at birth to obey musical stimulation in the right hemisphere", he concludes that the research points "to the great significance of lullabies in development, perhaps influencing the child's later creativity".

But it is in the difference between speech and song where we begin to pick up practical educational hints. Says the author (p. 365), "Speech, as has long been known, is a function primarily of the left hemisphere. But song . . . is primarily a function of the right." He then gives four illustrations, ending with daring the reader to think of a topic with which he is familiar, and then compose an extemporaneous song about it. The reason why this is next to impossible, he says, is that the song is in your right hemisphere and the cognitive topic in your left.

Pointing out that "lateralization of music can be seen in the very young" (p. 367), he describes an experiment with an infant showing that the right-hemisphere area is activated upon hearing music. He continues (p. 368):

> In the experiment I am describing, not only did the

> children who were . . . crying stop doing so at the sound of music, but they smiled and looked straight ahead, turning away from the mother's gaze. . . . This finding has immense significance for the possibility that the brain is organized at birth to obey stimulation in what corresponds to Wernicke's area on the right hemisphere. . . . It also points to the great significance of lullabies in development, perhaps influencing the child's later creativity.

One is certainly justified in extrapolating that perhaps the continuance of music education and singing is of considerable importance in pre-schools and elementary schools in its effect in stimulating the use of the right-hemisphere function. The Greeks, as usual, were on good ground in stressing the importance of music, and in connecting it with the Muses.

The casual reader might allow that such things go on in music and the arts, but hardly in the world of science, where the logic of the left-hemisphere should reign supreme. But, curiously, it is here in the area of scientific invention that we find the strongest case for the right-hemisphere imagery. Indeed, we may go further and assert that in the case of every historic scientific discovery and invention which is researched carefully enough, we find that it was imagery, either in dreams or in a waking state, that produced the breakthrough. We have the testimony of men such as Archimedes, Newton, Faraday, Agassiz, Hilprecht, Poincarè, Mendeleev, Kekulè, Loewi and others (Ghiselin, 1952; Gowan 1974) that this is so. Perhaps the most authoritative recent statement on the subject is that of Prof. E.S. Ferguson in *Science* (1977), who says in part:

> Many features and qualities of the objects that a technologist thinks about cannot be reduced to unambiguous verbal descriptions; they are dealt with in mind by a visual, non-verbal process. His mind's eye is a well-developed organ that not only reviews the contents of his visual memory, but also forms such new or modified images as his thoughts require.
>
> It is non-verbal thinking, by and large, that has fixed the outlines and filled in the details of our material surroundings. . . . Pyramids, cathedrals and rockets exist not

> because of geometry, theory of structures or thermodynamics, but because they were first a picture—literally a vision—in the minds of those who built them.
>
> Galton, speaking of "inventive mechanicians", observed that "they invent their machines as they walk" and see them in height, breadth and depth as real objects, and they can also see them in action". How to cultivate this "visualizing faculty" without prejudice to the practice of abstract thought in words or symbols was, to Galton, one of the "many desiderata in the yet unformed science of education".
>
> Much of the creative thought of the designers of our technological world is non-verbal, not easily reducible to words. Its language is an object or a picture or a visual image in the mind.

What research has now discovered is that imagery is the precursor of creativity in both the arts and sciences, that the right-hemisphere activity is the precursor of imagery, and that positive means of the right-hemisphere stimulation through art and music is equally as effective as other incubatory techniques for allaying the left-hemisphere function. Education is thus presented with a new and powerful tool in its efforts to make gifted children creative, and art and music education has received a research rationale of immense importance.

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Implications of Whole-Brained Theories of Learning and Thinking for Computer-based Instruction†

E. PAUL TORRANCE
University of Georgia

Frontier-thinking educators throughout the world are searching for ways of removing some of the unnecessary restrictions on learning and thinking and moving to a "no limits to learning" concept of education. This trend is reflected in the recent report of an international committee to the Club of Rome about future education (Botkin, Elmandjra, and Malitza, 1979).

I welcome this opportunity to discuss the implications of whole-brained theories of learning and thinking for computer-based instruction because I believe these theories offer very practical and promising clues that will aid in the search for a "no limits to learning" kind of education.

ANTIQUATED CONCEPTS OF THE MIND AND COMPUTER-BASED INSTRUCTION

A major obstacle to a "no limits to learning" kind of education is the antiquated concepts of the nature of the human mind *and* the nature of computer-based instrucation. In both spheres, the knowledge of teachers, eductional policy makers, and college of education faculties lags far behind actual developments.

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†Based on a paper presented at the ADCIS Conference at Atlanta in March 1981.

Concepts of the Nature of the Human Mind

Too few people have progressed in their understanding of the human mind beyond a rather superficial knowledge of the mental functionings reflected in intelligence tests. Bloom's taxonomy of educational objectives (Bloom, 1956), Piaget's (1969) developmental theories, and Guilford's (1967) Structure of Intellect Model have made some impact on frontier thinkers in education and have made some differences in the ways children are taught at home and in school. These theories deal only with minute portions of the human mind and are preoccupied with a rational view of learning and thinking. A landmark document which reflects this position is the 1961 report of the Educational Policies Commission which recommended that the "ten rational processes" become the central objective of American education. This Commission, however, did point out that the ten rational processes do not represent all of the human mind nor all of life. It maintained, however, that these ten rational processes represent the highest capabilities of the human mind.

This view represents an age-long bias of Western culture. Many of the Eastern cultures would maintain that the rational processes are important and essential but man's highest capabilities are in the realms of intuition and creativity, the supra-rational. As knowledge of Eastern thinking has become more widespread, whole-brained theories of learning and thinking have received more attention by frontier-thinkers.

Along with this trend, there has been a stream of research concerned with creative thinking; I have been involved in this line of investigation for the past 38 years. Theorists and practitioners in this field have long recognized that there are two basic patterns of learning and thinking: one in which the logical, rational mind is dominant and the other in which the intuitive, creative, non-logical mind and other states of consciousness are dominant. All of the leading models of creative thinking call for both patterns of information processing.

Osborn (1952, 1967) used the terms "critical intelligence" and "creative intelligence". He argued that these two kinds of intelligence could not function optimally at the same time and pioneered training methods for calling into play whichever kind of intelligence or information processing was needed. Others have used similar sets of terms to talk about the same phenomena. Edward de Bono (1970) uses the terms "lateral" and "vertical" thinking; Rollo May (1975) uses the terms "rational" and "supra-rational"; and William J.J. Gordon (1961) talks of the "intellectual" and the "irrational, emotional". In my work (Torrance, 1963), I have used the concepts of "learning creatively" and "learning by authority, by being told". In my NEA publication on *What Research Says to the Teacher: Creativity in the Classroom*, I argued as follows:

> . . . the weight of present evidence indicates that people fundamentally prefer to learn in creative ways—by exploring, manipulating, questioning, experimenting, risking, testing, and modifying ideas. Teachers generally have insisted that it is more economical to learn by authority. Recent research suggests that many things, though not all, can be learned more effectively and economically in creative ways rather than by authority. It also appears that many individuals have an especially strong preference for learning creatively, learn a great deal if permitted to use their creative abilities, and make little educational progress when we insist that they learn by authority. Such suggestions open exciting possibilities for better ways of individualizing instruction. (Torrance, 1977; p. 22.)

Somewhat parallel with these developments in creativity theory and research have been "dual-hemisphere", "split-brain", and "whole-brain" research. For ages, people have been interested in the specialized functioning of the right and the left cerebral hemispheres, and there has been a great deal of folklore associated with the topic. The topic, however, has continued to be shrouded in mystery and speculation until recently. Research in a great variety of disciplines has removed much of this mystery and has reduced the need for speculation. Some of the initial impetus for this research came from studies of brain-damaged patients but has been expanded to include people with essentially normal, well-functioning brains.

Whole-Brained Theories

Research conducted during the last several decades has shown the human left cerebral hemisphere to be specialized for primarily verbal, analytical, abstract, temporal, and digital operations (Bogen, 1969; Gazzaniga, 1970; Ornstein 1972). The same investigators have found the right cerebral hemisphere to be specialized for primarily nonverbal, holistic, concrete, spatial, analogic, creative, and aesthetic functions. The differences in preference of the two hemispheres for information processing have been referred to as styles of learning and thinking (Torrance, Reynolds, Riegel, and Ball, 1977) and as hemisphericity by Bogen, DeZure, TenHouten, and Marsh (1972).

Hemisphericity, briefly defined, is the tendency for an individual to rely more on one than the other cerebral hemisphere for information processing. Even though the role of the right hemisphere style in problem-solving and creative thinking has been reasonably well-documented (Krueger, 1976; Torrance and Reynolds, 1978), current and traditional public school teaching strategies appeal to and develop primarily the left cerebral hemisphere through their heavy emphasis on language processes and on the logical, sequential processing of information. Different methods, materials, and procedures are required for the development of the right hemisphere (Samples, 1975). Since a person's two hemispheres are able to function in a complementary manner (Bogen *et al.*, 1972), improvement in right hemisphere function often results in improved left hemisphere functioning, at least within the normally functioning human cortex.

The specialized functions of each hemisphere appear well lateralized and established early in life and, barring special intervention or insult, continue essentially unaltered throughout the normal life span (Zelinski and Marsh, 1976). Hemisphericity also seems to be established early in the preschool and primary grade years (Reynolds and Kaufman, 1978). Some evidence has been reported indicating that modifications in the tendency to rely on one or the other hemisphere during problem-solving is possible through modification of reinforcement contingencies (Gazzaniga, 1971) and through direct, extensive specialized training (Bever and Chiarello, 1974).

My own research (Reynolds and Torrance, 1978; Bracken and Torrance, in preparation) indicates that it is possible to modify a person's preferred style of learning and thinking over relatively brief periods of time (six to ten weeks). Not only are changes possible, but it seems that the general direction of the changes can also be controlled. As more is learned about the mechanisms controlling the development and alteration of styles of learning and thinking, it may become possible to train individuals to modify their information processing procedures to best fit the demands of their lives. While such training has obvious implications for the field of creative problem-solving, definite implications for computer-based instruction are also apparent.

Concepts of Computer Assisted Instruction

In talking with people about computer assisted learning, I generally find that they associate it with some of the early efforts in programmed instruction. They envision huge, expensive terminals with limited capabilities, enormous costs, and rigidity of programming. They are less familiar with the much less expensive and less ponderous microcomputers capable of visual, auditory, and kinesthetic modalities of expression. They are not aware that there was an estimated 10 million home computers in use in 1978 (Nelson, 1978) and that this number will be more than doubled by 1982.

Even some of the early programming research seems now to be related to whole-brained theories of learning and thinking. I do not know how widely this connection has been seen by experts in your field. Let me cite two studies that I think dramatize the importance of this implication.

The first of these studies involved fourth and fifth grade gifted students in language arts. It was reported by Gotkin and Massa (1963) and involved 42 highly intelligent fourth and fifth graders. They were provided 30 minutes per day of programmed instruction in language arts for a period of two months. The program used was the first four books of Susan Markle's *Words*. The subject matter was labelled "vocabulary building and word attack skills". Emphasis was placed on the ability to infer meaning. Prior to the initiation of the study, they had been administered both the verbal and the figural forms of the *Torrance Tests of Creative Thinking* (Torrance, 1974).

Gotkin and Massa (1963) reported that the subjects made significant gains as determined by pre- and post-tests of achievement, but it was the less creative students who made the greatest gains. The relationship between creativity scores and post-test achievement was − .34 and − .29. Gotkin and Massa found that many of the highly creative children expressed a strong dislike for this way of learning while almost all of the lower half of the creativity test distribution liked this way of learning. Apparently the highly creative children disliked this way of learning and failed to learn very much from it because it was contrary to their favored or best way of learning. They disliked being forced to make only tiny mental leaps because they were accustomed to making longer leaps and checking, testing, and correcting their errors. The less creative children, however, preferred the safety of the tiny mental leaps and the authoritative feedback of their errors.

A contrasting study was reported by Stolurow (1962) and involved measures of intelligence and measures of originality in relation to achievement following a programmed training experience. Stolurow's programming strategy was quite different from that in the Markle material used by Gotkin and Massa. With 20 high school students (aged 13 to 15), Stolurow and his associates conducted a summer institute in problem-solving. They used self-instructional materials in logic, mathematics, and statistics. These students were given three Guilford-type tests of originality (Consequences, Unusual Uses, and Plot Titles) and two Thematic Apperception cards with instructions to make up a story. The resulting originality scores correlated significantly with achievement on the statistics unit and with the final examination covering the entire program. The mental age scores on the intelligence tests did *not* correlate significantly with any of these scores of achievement.

Stolurow believes that auto-instructional materials should build specific, but multiple, associations to a stimulus. Since originality was operationally defined as the ability to make specific uncommon, but multiple associations to a stimulus, it was expected that post-training performance would be related to measures of originality. The instructional materials used by Gotkin and Massa called for linear, sequential processing of information, a specialized cerebral function of the left hemisphere while the Stolurow materials called for non-linear wholistic processing of information, a specialized function of the right cerebral hemisphere.

WHAT COMPUTERS ARE DOING

Look briefly at some of the things that computers are now doing and try to understand how they might be related to theories of whole-brained learning and thinking.

1. *Drill and practice:* Computers are used like "an electronic workbook" to reinforce concepts previously taught. This drill and practice may be conducted in such ways as to elicit either left or right cerebral hemisphere responses. If it emphasizes factual detail, it probably calls for left-hemisphere functions. If it emphasizes the "big ideas" in what has been studied, it probably calls for right hemisphere functions. If it calls for verbal responses and is conducted in the verbal modality, it probably calls for left-hemisphere functions. If it involves imagery and visualization, it probably calls upon right-hemisphere functions.

If children have difficulty in learning something, it is generally a good idea to consider their modality strengths and weaknesses. A child with poor auditory perception will learn more quickly by reading than being read to or given oral instructions. A child with poor auditory memory can learn to spell more quickly if his spelling words are presented as flash cards. Have him look at the words, close his eyes, and "see" the words. Later, say the word, then have him visualize it and write it.

If a child has poor visual memory, he will need to rely more heavily on phonics than sight words. Have him read or listen to the directions, then repeat them to himself silently. If he has poor visual perception, large print and few pictures will help. He can probably learn better from listening than from reading.

2. *Tutoring:* Computer-based instruction may perform a tutoring function by systematically presenting new information to the student with "branching" options depending on his or her responses. This is a natural for right-hemisphere functioning. However, it may emphasize logical, linear; sequential processing and, therefore, call for left-hemisphere functioning.

3. *Simulations and games:* When computer-based instruction makes use of simulations and games, students are presented with alternatives and must manipulate certain variables to produce desired outcomes. Again, both left and right hemisphere functions can be called into play. Such learning activities may be used to teach students to predict, estimate, judge the reasonableness of an answer, and to work with graphs, charts, and pictures.

4. *Information retrieval:* Left-hemisphere functioning is generally associated with the information retrieval role in computer-assisted instruction. Actually, this is determined both by the way the information is presented and the way it is processed after it is received.

5. *Problem-solving:* The student may use the computer as a powerful calculator in solving problems, and this is a natural for providing practice in whole-brained functioning.

Specialized Cerebral Functions of the Hemispheres

The list below of some of the specialized cerebral functions may suggest something of the variety of activities necessary in computer-assisted instruction to contribute to whole-brained functioning. List A consists of what seem to be some of the specialized cerebral functions of right hemisphere and List B includes parallel functions of the left cerebral hemisphere.

With the goal of "whole-brained" functioning and "no limits to learning", well balanced computer-assisted instruction would have to provide a variety of these kinds of activities. With children having strong modality and hemispheric preferences, however, an imbalance in the direction of these preferences might be necessary.

The instruments and tools available to educational psychologists for assessing hemisphericity and styles of learning and thinking are still quite crude. We use self-report instruments consisting of lists similar to the foregoing one (Torrance, Reynolds, Riegel, and Ball, 1977; Torrance and Reynolds, 1980), eye movement tests (Bogen, 1969; Bogen *et al.*, 1972; Reynolds and Kaufman, 1978), and tests derived from the field of neurolinguistic processing have been very useful and will continue for some time to be refined further and used to facilitate the learning of children. It should not be long, however, before much more effective devices emerge from the field of computer-assisted instruction. Already the field of medicine (Berger, 1981) has a variety of computers for assessing and diagnosing brain functioning. Perhaps the best known of these is the CAT (Computerized Axial Tomography) Scan machine which combines X-Rays with a computer and reveals the depth as well as the width and length of body tissues. Its original purpose was for use in examining the brain, and it has been especially useful in diagnostic work with stroke victims and similar brain disorders. Along with the CAT Scan machines have been the use of ultra sound techniques, PET scanning (Position Emission Tomography), Nuclear Magnetic Resonance (NMR), and the like. It may not be long before similar kinds of computer devices can be used in education and become a part of computer-assisted instruction.

IMPLICATIONS FROM CHILDREN'S RECOMMENDATIONS

In choosing problems to be studied in the Future Problem-Solving Program (a national program involving over 75,000 gifted students in grades 4-12 in 49 States) (Torrance, 1980), participants gave the highest vote this year to the increasing use of home computers. Different assignments were given to each of the three educational levels: Juniors, Grades 4-6; Intermediates, Grades 7-9; and Seniors, Grades 10-12. The assignment given to the Junior Division has the most direct relevance for our topic today. This assignment was stated as follows:

> With many of you being familiar with programmed games, learning to use a microcomputer or home computer will be very easy. We hope that many of you have had an opportunity to "play" with, or to see a microcomputer in use.
>
> Now your assignment is to consider your term as a

Specialized Information Processing Preferences associated with Hemisphericity

List A

—reading for main ideas
—searching for hidden possibilities, uncertainties
—recalling pictures and images
—thinking of images, pictures
—thinking intuitively
—making predictions intuitively
—dealing with several things simultaneously
—having sudden insights
—playful and loose in experimenting (cooking, research)
—writing fiction
—being absent-minded sometimes
—watching and then trying to do it
—remembering facts picked up from things going on
—creating, improvising in hobby
—playing hunches
—organizing things to show relationships
—expressing feelings through poetry, song, dance, art
—remembering sounds, tones
—inventing things, procedures
—drawing own images and ideas
—listening to music while reading or studying
—learning from demonstrations
—learning experimentally by doing

List B

—reading for specific details
—searching for what we can be sure of, established truths
—recalling words, names, dates
—generating word thoughts
—thinking logically
—making predictions systematically
—dealing with one thing at a time
—building a line of reasoning to a conclusion
—systematic and controlled in experimenting
—writing non-fiction
—almost never absent-minded
—hearing verbal explanation and establishing a sequence of steps
—remembering only things specifically studied
—collecting things
—betting on a sure thing
—organizing things sequentially (time, size, importance, etc.)
—expressing feelings in plain language
—remembering verbal materials
—improving things, procedures
—copying, filling in details
—getting things quiet while reading or studying

—day-dreaming
—open ended instruction
—responding positively to emotional appeals
—learning through exploration
—learning geometry
—using analogy and metaphor
—summarizing material studied
—remembering faces
—interpreting body language
—approximating, estimating
—saying/doing humorous things
—synthesizing ideas
—improvising
—drawing, model building
—assuming
—lying down and thinking

—learning from verbal descriptions
—learning through logical reasoning
—planning realistically
—knowing exactly what to do
—responding positively to logical appeals
—learning through examination
—learning algebra
—using plain language
—outlining things studied
—remembering names
—depending upon what people say
—measuring with precision
—saying/doing well-reasoned things
—analysing ideas
—using the correct thing
—describing things verbally
—verifying
—sitting erect and thinking

representative committee who have been asked by the local School Board to be consultants for a very difficult problem which has arisen in your community. Because all the families in your community have home or microcomputers, the School Board has discontinued the local school system and all teaching is done by computers. However, just as in "the olden days" of 1981 some children are not paying attention. They prefer to play games or "goof off" by communicating with friends. The achievement scores for all subjects have fallen so low that the School Board is considering returning all children to the "basics of 1981" where children are in an assigned classroom.

What kinds of problems would the inattention of the children raise? What worries might parents have in this situation? What challenges to all community members would arise from children failing to learn from computers? Remember your team members are the consultants to investigate the problems and seek solutions for them.

My associates in the Georgia Statewide Future Problem-Solving Program, as well as programs in 19 other States, are now evaluating the solutions submitted by the elementary school students in the program. I scanned some of their recommended solutions and extracted a sample of 50 of them. I believe that you will find this sample of 50 alternative solutions to be instructive. Apparently, these gifted elementary school students intuitively sensed the need for computer-based instruction to provide for whole-brained functioning. You may take your own analysis of these 50 alternative solutions.

1. Have more computers that sing.
2. Make the activities more fun.
3. Make lessons that are fitted for each person.
4. Make computers talk to children.
5. Do not have all learning on computers.
6. Have two different kinds of computer terminals and two different kinds of tape systems.
7. Kids would have access to computer tape libraries where

they could check out extra tapes if they finish their work fast on the flexible time week, so they could learn even more.

8. Students would decide which system they wanted to use and that system would be programmed.
9. If studying a particular subject, students would be able to hook up on a TV monitor and speak with people in other countries.
10. Program subjects as games which would be given to each child to work on a weekly basis so they could divide their time up more the way they wanted to.
11. Use games or learning activities where two or more students have to work together.
12. Use discs that give experience in job training by simulating different job experiences.
13. Have computers that students talk to.
14. Have the kids do experiments by computer instruction.
15. The software could include programs for making things and the machine could store preferences.
16. Special teachers could do special things with students. Once a child completed his work on the computer, he could go to the special teacher.
17. Program computers to use color, graphics, animation, and some unusual sounds in teaching interesting subjects such as science and mathematics in order to hold children's attention, making learning fun, and keep them on task.
18. Use cartoon figures.
19. Use many different colors.
20. Use lots of different graphics.
21. Use many different unusual tunes.
22. Use many different sounds.
23. Program computers to use student's name in lessons.
24. Computers ask children different kinds of questions.
25. Program computer to tell you the percentage of what you got right.
26. Different computers for different kinds of abilities.
27. Use interesting music for some subjects.
28. Program the computer to let the children watch educational programs on TV.
29. Program the computers so they can talk to the children so

that they won't have to read all day long.

30. Program computers to teach about the future and present environment, not just the past.
31. Have the computer interest them in outdoor games and activities in which they have to come back and answer scholastic questions.
32. Program computers to ask educational questions about outdoor sports.
33. Computers could tell interesting, funny stories between exercises.
34. Let children select activities of their choice between required studies.
35. Program puzzles between computer classes.
36. Have cartoon characters to tell children what to do.
37. Link learning into games.
38. Combine computers with finding out experiences outside the computer room.
39. Have tapes that involve moving about and doing things and not all reading or listening.
40. Make the computers have a little bit of feelings.
41. Have computers to teach special skills.
42. Have groups with about five children in each and have them make up stories and things on the computer.
43. Let the children invent games for the computer.
44. Use problems that they will face in everyday life and make the children solve them by themselves.
45. Have a computer that will have them go out every day and do a real problem and come back and check it through the computer.
46. Program the computer so students will have to communicate with one another and get information from one another.
47. When students have successfully completed a program have the computer teach them art and let them do some art.
48. Have it so they get some kind of reward for doing good work.
49. Program something to get the kids excited about learning the lessons to follow.
50. Turn problems into games and use a point system to give results.

A MODEL FOR PUTTING IT ALL TOGETHER

In a number of other sources, I have proposed an instructional model of a sort to provide a structure or framework for putting together a variety of learning experiences in such a way as to provide for whole-brained learning and thinking (Torrance, 1970, 1979a, 1979b). In this model, I have argued that the process of incubation is the key element involved in putting together the specialized functions of the left and right cerebral hemispheres. I have maintained that incubation should be regarded as a higher level thought process that goes beyond logical, rational processes, and one that can be enhanced through practice and instruction that encourages higher states of consciousness beyond the logical, wakeful state; combines intellectual, volitional, and emotional functions; provides realistic encounters calling for intense absorption, involvement, and commitment; calls for simultaneous confrontation of opposite, contradictory, or antithetical concepts, images, or ideas; and involves the interplay of two or more sensory modes of thought. The framework has been suggested for a model of instruction designed to provide these conditions. This three-stage model provides for an introductory phase which arouses anticipation and heightens expectation, a second phase which deepens involvement and commitment and goes beyond the superficial, and a third phase which keeps the thought processes going and results in increased chances of successful incubation.

The kind of learning envisioned includes but goes beyond what Botkin, Elmandjra, and Malitza (1979) refer to as "maintenance learning". It would be a kind of innovative learning whose primary characteristics would be anticipation and participation. Anticipatory learning, as described by Botkin *et al.* (1979), prepares people to use such techniques as forecasting, simulations, scenarios, and models. It encourages students to consider trends, to make plans, to evaluate future consequences, and possible injurious side-effects of present decisions and actions. Participatory learning involves getting beyond words. Students want to be partners in decision making, are unwilling to accept duly limited roles, and desire to live life more fully.

CONCLUSION

As an outsider who knows very little about what you are doing but as one who has very high hopes about what you will contribute to education, I would like to challenge you to make a reality of the dream of "no limits to learning". I believe that the "whole-brained" theories of learning and thinking that I have reviewed will provide clues that can be developed into tools for accomplishing the dream of "no limits to learning".

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Hemisphericity and Neuropsychological Approaches in Education: Evidence for an Aptitude × Treatment Interaction—And a Caution

CECIL R. REYNOLDS
Texas A & M University

One of the most rapidly growing areas of interest in the evaluation of exceptional children is that of neuropsychological assessment; it is also becoming one of the most controversial areas of assessment in education. Neuropsychological assessment was the subject of a debate at the 1981 annual meeting of the American Psychological Association chaired by Lawrence Hartlage and titled with the question "Can neuropsychology contribute to rehabilitation in educational settings?" Several well known, respected scholars from education and from neuropsychology took opposite sides of the issues.

Much of the controversy surrounding neuropsychological assessment stems from three factors: (1) A simplistic view of clinical neuropsychology as merely a set of tests, (2) a naive belief that neuropsychological testing will always result in a vague and useless designation of a child as having minimal brain damage or minimal brain dysfunction (MBD), and (3) rejection by many of a nomothetic approach to the amelioration of childhood disorders. For the last three decades, clinical testing in neuropsychology has been dominated by the Halstead-Reitan Neuropsychological Test Battery (HRNTB), though the Luria-Nebraska Neuropsychological Battery is now making considerable inroads. The prevalence of use of the HRNTB is largely responsible for perceptions of clinical neuropsychology as primarily a set of testing techniques. However, a brief examination of the HRNTB should quickly dispel such notions. The HRNTB consists of a large set of tests taking a full day or more to properly administer, yet there is little that can be said to be psychologically or psychometrically unique about any of these tests. They are all more or less similar to tests that psychologists have been using for the last 60 years or so. Far from being a set of techniques, the major contribution of neuropsychology to the assessment process is the provision of a strong paradigm from which to view test data. A major neuropsychological paradigm, and the subject of this volume is hemisphericity, i.e., the tendency for individuals to rely more on the information processing style of one cerebral hemisphere than another in their daily functioning. Determination of hemisphericity relies principally on neuropsychological testing, though other indirect but crude measures are available. Yet, even the concept of hemisphericity is a controversial one (e g., Kinsbourne, 1982) despite its appeal to educational and rehabilitative efforts.

Without the provision of a strong paradigm, clinical neuropsychology could not have progressed to the point of applicability and generalizability that has emerged today. As with other areas and subspecialities of psychology, several competing paradigms and theories exist in clinical neuropsychology, and any one of these may be the most appropriate for interpreting data for any individual child and for developing the best educational approach possible (e.g., Ayres, 1974; Das, Kirby, and Jarman, 1979; Luria, 1966; Pribram, 1971; Reynolds, 1981a,b; Tarnopol and Tarnopol, 1977; Wittrock, 1980). It is thus crucial to achieve an understanding of the various neuropsychological models of higher order human information processing in order to be effective in translating test results into meaningful educational programs, i.e., teasing out the aptitude × treatment interaction for a single individual. Contemporary neuropsychological theories of the intellect and its function are presented in a number of sources (e.g., Das, Kirby, and Jarman, 1979; Kolb and Whishaw, 1980; Luria, 1966; Pribram, 1971; Reynolds, 1981b; Wittrock, 1980). Well-grounded, empirically evaluated theoretical models of neurological function enable one to make specific predictions about how children will perform under a given set of learning circumstances. Of course, one will not always be correct, but a good theory from which to work allows the psychologist to narrow down the number of alternative hypotheses (methods of remediation) considerably. Without a viable set of theories, one would be completely a stimulus-bound technician relying entirely on trial and error experience and more or less shooting in the dark whenever encountering a child with a set of behavioral nuances and test scores not previously seen, i.e., "nothing is so practical as a good theory".

Far from designating every child evaluated as MBD or otherwise neurologically impaired, neuropsychological assessment methods can make an important contribution by ruling out specific neurological problems and pointing towards environmental determinants of behavior. The well-trained neuropsychologist is certainly aware that the brain does not operate in a vacuum, but is an integral part of the ecosystem of the child. Neither are neuropsychological models of cognitive functioning inconsistent with the use of behavioral technology. Descriptive neuropsychological assessment of a child can provide pertinent information regarding the child's most well-developed or preferred mode of information processing and behavioral methods can then be employed to affect the motivational factors related to the acquisition of new knowledge and skills. Neuropsychological approaches to the habilitation of learning are applicable to both special and regular education programs. Each of these areas is addressed below.

NEUROPSYCHOLOGY AND EDUCATION OF THE EXCEPTIONAL CHILD

Descriptive Neuropsychology

The evidence for the relationship between behavior, particularly academic or intellectual behavior, and the functional integrity of the brain is enormous and has for the most part been reviewed by Gaddes (1981) and need not be reiterated here. What is clear from Gaddes' review is that a comprehensive neuropsychological evaluation can provide an accurate description of the information processing strategies of the child's brain. Neuropsychological assessment also has value to the neurologist in describing the effects of trauma to the central nervous system, but this will not be of concern here. Having its historical basis in the needs of the neurologist, however, neuropsychological assessment methods have been used in studies of the localization and extent of neurological dysfunction. A strict localizationist approach to the interpretation of psychological test performance has drawn considerable criticism from the educational community, and indeed there are alternative approaches within neuropsychology itself. Acceptance or rejection of the anatomical localization hypotheses of neuropsychological test data is really irrelevant to the educational or rehabilitative implications of neuropsychological test data. What is important is the knowledge that certain neuropsychological skills cluster in a similar manner for most children, leading to an advantageous position for diagnostic personnel in their ability to select a teaching method that capitalizes on the intact skill areas when designing remedial programs.

Can one actually design a better remedial program when neuropsychological test data are available than when they are not present? Of course, this depends upon the skill of the clinician. Assuming a psychologist well trained in neuropsychological testing methods and knowledgeable in theories of cognitive development, information processing, and psychometrics who has access to a curriculum expert (e.g., the child's resource teacher), the answer must be "Yes, for the majority of the children." The ability to describle and diagnose outstrips the ability to treat in neuropsychology just as it does in most clinical sciences, and there will always be problems accurately diagnosed for which there are no foolproof treatments. Some would argue vehemently against diagnosing and/or labelling children we are unable to properly treat. This, of course, is absurd. How would we ever learn to treat such children if we didn't know who they were or exactly what their problems were? Even the most radical of anti-testing, consultation-oriented models of delivering psychological services in the schools note problem identification as a major component of the problem-solving process (Gutkin and Curtis, 1982).

Remedial Approaches

The evidence for the neuropsychological aptitude × treatment interaction in the remediation of learning and behavior problems is diverse, ranging from case studies, to correlactional analysis, to an occasional experimental study. Some approahes to the study of the neuropsychological aptitude × treatment interaction work backwards, first locating groups of learning problem children in specific instructional programs and evaluating their common neuropsychological deficits All are valid as well as necessary approaches to the issues as we are deavaling with humans and cannot manipulate their lives, enaronments, and physiological status to meet the demands of the researcher. Parents for example have been found to be dramatically resistant to allowing commissurotomies on normal children for the purposes of research on learning. Case studies now abound demonstrating the efficacy of a neuropsychological approach to the remediation of learning disabilities and can be found in a variety of sources (e.g., Hartlage, 1982; Hartlage and Givens, 1982; Hartlage and Reynolds, 1981) with one of the earliest and most cogent examples given by Luria and described in Tarnopol and Tarnopol (1977). These approaches tend to be most effective when the child's most effective mode of information processing is determined and instructional strategies implemented that rely heavily on those processing methods.

A variety of studies of children with poor reading performance from such diverse groups as the mentally retarded, learning disabled, and socioeconomically disadvantaged has demonstrated that a neuropsychological deficit in the use of successive or sequential information-processing strategies is a quite common occurrence in all of these groups (e.g., Blackman, Bilsky, Burger, and Mar, 1976; Cummins and Das, 1980; Das, Kirby, and Jarman, 1979; Das, Leong, and Williams, 1978; Krywaniuk, 1974; Leong, 1974), leading toward two approaches to remediation. The first is a deficit-centered approach which would teach these children to use their successive information-processing skills in a more effective manner. While deficit-centered remedial approaches have not faired well in the past (e.g., see Reynolds, 1981a,b; Ysseldyke and Mirkin, 1982), the ability to use a particular mode of information processing (i.e., successive processing vs. simultaneous processing; these two information processing strategies have been directly related to left and to right hemisphericity respectively by Reynolds, 1981b) does seem amenable to change with specific training (e.g., Bever and Chiarello, 1974; Grissom, Hobby, Otey, and Warden, 1982; Reynolds and Torrance, 1978) and is likely to be controlled by traditional principles of reinforcement. However, little is available regarding the generalizability of such training in cognitive processing skills to academic tasks such as reading. Schooling is a very language-based task and language phenomena are most efficaciously processed via successive information processing, so there may be considerable residual or sleeper effects from effective training of young reading disabled children in the use of successive processing strategies, and this approach deserves the careful, considered attention of researchers in special education and instructional psychology.

A more direct approach to remediating deficits is to alter instructional styles and materials to best fit the most preferred processing approach of the child in question, capitalizing on existing strengths and limiting the effects of his/her disability as much as possible. This approach following the remediation maxim stating that if a child does not know how to read, the best remedial approach is the one that teaches the child to read. Cognitive deficit approaches would identify a poor skill such as successive processing (as noted above) and train this skill instead, hoping that it would generalize to academic tasks such as reading. Neuropsychological strength models on the other hand have intuitive appeal and can save considerable emotional anguish by focusing on what the child is best as opposed to worst at performing in addition to directly teaching the academic skills that are deficient. For the simultaneous and successive model of neuropsychological processing (Das *et al*., 1979; Reynolds, 1981b) the teaching technology is available. Gunnison, Kaufman, and Kaufman (in press) have provided a series of strategies for the development of instructional methods matched to the child's successive or simultaneous processing skills in the teaching of reading. Other neuropsychological models may be more appropriate for specific children however, as no single model is likely to fit all children. Indeed, trying to force all learning problem children into a single mold has been a major problem in research on the nature and remediation of learning disorders.

NEUROPSYCHOLOGY AND REGULAR EDUCATION

Neuropsychological approaches to the interpretation of traditional psychological tests may ultimately prove more beneficial in regular education programs by playing a primary prevention role and by affecting larger numbers of children. Normally functioning children as well as adults tend to have an habitual mode of neuropsychological information processing (Das *et al.*, 1979; Reynolds, 1981b; Reynolds and Kaufman, 1978) that has also been referred to as *hemisphericity* (Bogen, DeZure, Tenhouten, and Marsh, 1972; Reynolds, 1981b). Hemisphericity, as previously briefly defined, is the tendency of an individual to rely primarily upon the problem-solving or information-processing style of the right (simultaneous processing) or left (successive processing) hemisphere of the cortex. It is important to understand here that hemisphericity is conceptualized as a type of dominance for an information processing style and is independent of traditional notions of lateral preference markers such as handedness, eyedness, or footedness (Reynolds, 1981b). It follows that if an individual's preferred mode of information processing can be determined, instructional methods aimed specifically at these modes of processing should be more effective than randomly assigning children to instructional programs.

One rather poignant example of how tests of common psychological abilities can be interpreted from a neuropsychological paradigm to the benefit of large groups of normal children has been provided by Hartlage and his colleagues (Hartlage, 1975; Hartlage and Lucas, 1973a,b). An entire first grade class was administered a group test battery which allowed classification of the children into one of several groups on the basis of relative efficiency of demonstrated information processing in the areas of visual sequencing, auditory sequencing, and auditory and visual space. Following classification into one of these groups on the basis of a relatively (i.e., ipsatively determined: see Kaufman, 1979; Kaufman and Reynolds, in press; and Reynolds and Clark, in press, for an explanation of ipsative test score interpretation methods) stronger performance in that area of function, the groups were matched with a specific reading program for instructional purposes that was believed, on the basis of a logical analysis, to capitalize on the child's identified cognitive/neuropsychological strengths. Children performing best on visual sequencing were taught reading through the use of the initial teaching alphabet (ITA) approach, which is heavily dependent on such skills. Children who earned their highest levels of performance on the auditory sequencing tasks were taught reading through a heavily linguistic, phonics approach. Children excelling principally in the areas of visual and auditory space were taught reading in a system relying primarily on a traditional orthographic, whole-word, look-say approach. Due to some logistic requirements of the school where the study was conducted, slightly more than half (684/1132) of the children were randomly assigned to an instructional method according to their information-processing strengths as described above.

At the beginning of school, mean Metropolitan Readiness Tests' scores were essentially identical for the control and experimental groups, differing by less than one raw score point. At the end of the first grade, after nearly a full year of instruction in reading as detailed above, all children were administered the Reading subtest of the Wide Range Achievement Test. The mean standard score in reading for the control group was 106; the experimental group that had been matched with an instructional method on the basis of their test performance earned a mean standard score in reading of 129. The teachers' ratings of the children's global reading skills were significantly correlated with their reading achievement test scores indicating that the large mean differences between the experimental and control groups were not an artifact of the reading assessment method.

The tests used to screen this sample of children for placement in an instructional program are not specifically neuropsychological tests, but rather were interpreted from a neuropsychological paradigm. In this instance, the model for interpretation coincides well with that presented by Tarnopol and Tarnopol (1977). This paradigm allows one to accurately relate cognitive performance on specific tests to those complex functional systems of the cortex mediating such activities. Programs are then designed that match-up with the most efficacious information-processing methods for the individual child in question. The simple screening procedures described above undoubtedly prevented considerable early reading failure among the experimental group. Such interpretations, however, require considerable knowledge of neuropsychological theory and of differential psychology.

Adult students, presumably knowledgeable, at an unconscious if not always conscious, level of their preferred mode of neuropsychological information processing, when given a choice between classrooms using successive-processing oriented techniques versus simultaneous-processing oriented techniques most often choose the classroom that matches their own habitual mode of processing and tend to learn more material under such circumstances (Krashen, Seliger, and Hartnett, 1974). While hemisphericity is developmental in nature, it appears well established in many children by age 4 and most by 5½ to 6 years (Reynolds and Kaufman, 1978). Ogletree (1978) has provided several suggestions for curriculum changes to provide broader appeal to children with a variety of habitual modes of information processing.

A number of neuropsychological models are available for relating test results to instructional planning. A very important, and perhaps the single most important, variable in the algorithm is the neuropsychological theory one follows when making interpretations. The theory must have validity. Our theories are certainly imperfect, but are improving. Psychological tests, in the cognitive sphere, have not typically been designed from the basis of sound theory, but rather a rigid empiricism has ruled. Empirical derivation is necessary but insufficient. Tests currently under development that are empirically tested and designed with a strong foundation in neuropsychological theory (e.g. Kaufman and Kaufman, in press) should significantly enhance our understanding and skill in developing remedial processes from psychological test data. However, one aspect will always remain clear: as long as children exhibit individual variations in behavior, cognitive skills, and academic attainment, we must work from the nomothetic framework provided by theory or else be stymied when each new variation is encountered. The aptitude × treatment interaction is perhaps going to be as individual as the learner and strong theories and highly skilled clinicians are going to be a necessity if there is to be any hope of teasing out the interaction for individual children in any consistent fashion.

HEMISPHERICITY AND EDUCATION OF INTELLECTUALLY GIFTED AND CREATIVE CHILDREN

The concept of hemisphericity can be applied to the education of highly intelligent and/or highly creative children as much as it is applied to handicapped and regular education children, with but a slight conceptual modification in one's thinking. Hemisphericity exists at all levels of general mental ability (Das *et al.*, 1979), and right or left hemisphericity is *not* what sets the gifted child apart. In the enthusiasm of the potential contribution of neuropsychology to education, we sometimes overlook the role of general mental ability or what Spearman (1904) termed *g*. The overall level of *g* for the most part determines how well one processes information and has been referred to as biological intelligence (Reynolds, 1981b). Hemisphericity is more directly related to the specific methods of information processing and has been referred to as psychological intelligence (Reynolds, 1981b).

Once *g* has been properly taken into account, hemisphericity can be profitably used to enhance instructional styles and curricula for gifted children. Training in simultaneous processing (i.e., right hemisphericity) may very well enhance the creative skill of high IQ children. Right hemispheric high IQ children display higher levels of creativity, even on language related tasks, than do left-hemisphere oriented, but otherwise comparable, high IQ children (Torrance and Reynolds, 1978). Right hemisphericity and highly integrative processing strategies can specifically be trained in these children (Reynolds and Torrance, 1978). In the complex state of today's world society, we must look to highly intelligent, highly creative leaders for direction and perhaps even basic survival. By employing the concept of hemisphericity in the education of these children, perhaps we can enhance their thinking and learning as well as their positive impact on the future. This can be most efficaciously accomplished by taking appropriate advantage of the individual's information-processing strengths but with at least some time devoted to the teaching of "integrative hemisphericity" or cerebral complementarity.

A CAUTION

It is proper to close this otherwise rather optimistic paper with cautions from several fronts regarding the application of neuropsychological information to education. Perhaps the most general of cautions is also the most important one: Do not allow the cart to get before the horse. Basic research in neuropsychology and testing of brain-behavior relationships must guide the development of educational programs that are purported to be steeped in neuropsychological theory. Education is prone to faddism and political pressures. As reviewed by Glass (1981) and by Reynolds (1981b), previous neurologically based theories of remediation have been dismal failures, and were almost without exception implemented without sufficient research (and were also deficit models). Once remedial programs become entrenched, politics, dissonance reduction, and lethargy (comfort with one's training coupled with inertia regarding learning new methods) make it extremely difficult to eliminate such methods in spite of repeated demonstrations of the ineffectiveness of such programs. The remedial programs promulgated by Doman and Delacato, derived essentially from Orton's neurological view of learning, serve as a prominent example of this problem. Despite the lack of empirical support for the Doman and Delacato approach, the refutation of its underlying theory (Corballis and Beale, 1976; Reynolds, 1981b), its condemnation by many major national and international professional organizations associated with services to exceptional children (Levine, Brooks, and Shonkoff, 1980), and concerns that it may be emotionally harmful to children and their parents, some school districts in the United States continue to employ Doman and Delacato programs as the primary treatment model for exceptional children within their jurisdiction.

There now appears to be somewhat of a bandwagon effect occurring with regard to the direct applications of recent neuropsychological knowledge to education that presents another danger. Many are grasping at "potential implications" as "hard fact", perhaps due to the ineffective nature of much of special education. Experimental approaches to remediation are being taken and applied by the neuropsychologically naive without refinement or sufficient empirical support. Much of our knowledge in neuropsychology has been generated over the past 10 years and there has not been sufficient time for proper translation of this knowledge into educational practice. The number of highly skilled neuropsychological technicians who can accurately translate the myriad of neuropsychological test data into a meaningful remedial or habilitative program are too few to meet the present needs and the unskilled are being pressured into such service. Neuropsychological approaches to education hold great promise as presented here and in other papers of this volume, but promise that may not be allowed to come to fruition or even be thoroughly assessed if we are not more careful. More than one good idea has died a premature death when implemented in an undeveloped state without sufficient empirical support. Under such circumstances, programming decisions are likely to be made which are simply too far ahead of the existing data and/or theory to be adequately accurate. Caution must be the watchword or else a potentially valid technology may be lost to disillusionment.

There is also much yet to be learned in neuropsychology even as the knowledge explosion continues in this arena. Though more than 1,000 articles relevant to neuropsychology and learning have been published in the past decade (e.g., Reynolds, Riegel, and Torrance, 1977), far more questions than answers have been generated.

Neuropsychological assessment techniques are also woefully in need of refinement (Reynolds, 1981c). The systematic development and presentation of normative data have received far too little attention in neuropsychology. Too much of neuropsychological data are based on the performance of known impaired samples; not enough is known about how normal individuals respond to neuropsychological test batteries. Many neuropsychological evaluation methods lack adequate study of their basic psychometric characteristics, most notably in the area of reliability. Dichotic listening and split-visual field techniques are very popular methods of assessment in neuropsychological research and have been recommended for immediate application in school settings. The reliability of these techniques is poor from a psychometric perspective, the reliabilities reported (albeit infrequently reported) in the literature typically range only from .50 to .65 (Reynolds, 1981c). There is also a disturbing tendency in neuropsychological research on learning disorders to report children's performance in terms of age or grade equivalents, a practice distorting the make-up of what are believed to be well-defined clinical subgroups under study (Reynolds, 1981c,d).

The HRNTB, the old guard of neuropsychological testing, has been subjected to a number of conceptual and psychometric criticisms as of late. The battery is poorly normed by psychometric standards, especially as regards children. Hevern (1980) and Swiercinsky (1979) have concluded that the HRNTB does not allow for the independent assessment of a sufficient number of cognitive processes to provide adequate coverage for program development. Research on the HRNTB is unfortunately plagued by a number of methodological problems, including inadequate subject descriptions and sampling procedures that severely restrict the generalizability of work in this area. The Luria-Nebraska Neuropsychological Battery has also come under considerable fire, and lies at the center of a major controversy in neuropsychological testing (e.g., Adams, 1980a,b; Golden, 1980; Spiers, 1981). The Luria-Nebraska has been criticized on the basis of inadequate reliability, validity, item content, administration and scoring procedures, and as a bastardization of Luria's own methods. Golden (1980) has staunchly defended the Luria-Nebraska and heads a major research effort on this scale. It is unlikely that the controversies regarding the Luria-Nebraska will be satisfactorily resolved in the near future. Much more data are needed, but such is the plodding nature of science. Yet this controversy as well as the criticisms of the well established HRNTB are indicative of the unsettled youth of clinical neuropsychology, a rapidly growing field, pregnant with ideas and hypotheses that *may* prove of considerable utility in educational theory and practice.

Thus, caution must be the watchword in applying neuropsychological knowledge to education. To be successful, one must stick close by the existing data, extrapolating very little, if at all. Perhaps it would be even better to lag slightly behind the available data and technology. As with other methods of assessment, it must be pointed out that used wisely and with skill, neuropsychological assessment has much to offer special and regular education; poorly, carelessly, or hastily implemented, it can create seriously false impressions, lessen expectations, and promulgate a disastrous state of affairs for the very children it is designed to serve. If not careful, neuropsychology may even promote itself out of the education establishment prematurely by attempting to go too far too fast. More data are coming regarding the ability of neuropsychology to make large-scale contributions to education. For now it looks promising and we are ethically bound to use this knowledge to assist children where sufficient knowledge exists. In other areas we must await the data. If it is supportive, it will have certainly been worth the wait; if it is not supportive of our speculations, could we really have afforded not to wait?

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Psychology of Adolescence

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S.S. CHAUHAN

It is universally acknowledged that adolescence is the most crucial period in the life span of human beings when a number of changes occur in physical, intellectual, emotional and social dimensions of development. Adolescence has acquired a prominent position in developing countries which are determined to accelerate the pace of national development with the help of enormous human power of adolescents. It goes without saying that the interest in the study of adolescence awakened after a long intellectual sleepiness in developing countries who have recognized the importance of adolescents in national development.

The author has made an effort to present the subject matter in such a way that it may prove useful to parents, teachers and students of various categories, help them to understand the developmental characteristics and problems of adolescents and to guide them properly for better adjustment in life.

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